C O P Y

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GRASSLAND AGRICULTURE AS A FACTOR IN WILDLIFE MANAGEMENT

Grassland farming is a balanced system of farming designed to avoid waste of soil and fertility by erosion, leaching, and excessive plowing. While the procedure that will be followed in grassland farming varies in detail from place to place it will in general involve the following four general considerations:

1. Using the most productive, least erodable fields for row and grain crops in rotations that include at least one and preferably two years of forage grasses and legumes.
2. Maintaining rolling lands in rotations which include productive grasses and legumes as long as possible between cultivated crops.
3. Keeping washing hillsides in grasses and legumes all the time but assuring high production by periodic renovation.
4. Fencing out the steepest slopes to keep out cattle and maintaining them permanently in trees.

Contrary to fears which have been expressed by some the program of grassland agriculture outlined above does not stand in the way of your program of wildlife management. In fact, it may well serve to amplify and strengthen certain phases of a sound, properly integrated wildlife management program. The following may serve to illustrate where such advantages may accrue: 1) better, more productive forages mean better cover for shelter, concealment, and nesting; 2) improved production of forage elsewhere on the farm removes the necessity of grazing from woodlots which are thus made available for long range planning for timber production and the development of wildlife; 3) stream banks now grazed bare could be fenced and cover permitted to grow, thus providing better habitats for fish and game.

Grassland agriculture makes every acre count by putting it to its best possible use. It offers a realistic and practical means of achieving permanency in agriculture -- an agriculture that can be depended upon to satisfy our future needs for food, fiber and shelter for ourselves and of feed and shelter for our domestic animals and for our wildlife -- an agriculture that provides assurance of a continuing standard of living sufficiently high to make it attractive as a profession to the youth of America. There is no implication here that the full use of the land is denied to any who are interested in the many phases of conservation. As we see it now grassland agriculture provides the only practical method in existence for effectively utilizing our soil--- our most important natural resource -- while at the same time conserving and safeguarding it and the plants and animals it supports permanently for posterity.

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Studies on Smallmouth Black bass in Iowa Streams: Stream Dynamics and Smallmouth Movement

by
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The study of the smallmouth in northeastern Iowa streams was begun in July 1947 and has continued to-date. One phase of the study has been an attempt to learn the extent of the movement of the smallmouth. It had been noted by Dr. William Starrett in his forage fish studies on the Des Moines River near Fraser, Iowa that game fish reproduction, including the smallmouth, was not successful in the period 1945-47. During this period, however, Dr. Starrett and Mr. Harry Harrison of the Iowa Conservation Commission found smallmouth reproduction in even the intermittent tributaries of the Des Moines. Spawning conditions were unfavorable in the Des Moines because of floods throughout the spring and early summer during this period.

The spring of 1947 was also characterized by torrential rains and floods. Even the small streams were bank-full and turbid. Coffin Creek near Manchester in Delaware County had cleared sufficiently that observations and angling were begun on July 9, 1947. The flood had created many large pools and both observation and angling indicated a large population of adult smallmouth in the 2 1/2 mile reach of Coffin Creek immediately above its mouth on the Maqucketa River. Spawning continued sporadically until the first of August. During the summer 67 smallmouth were caught and removed from the study area. Of these 60 were mature.

During 1948 frequent observations were made in the Coffin Creek study area. Observations were begun on March 12 and the water level did not reach flood stage after that time. The filling of pools by drifting sand, noticed in 1947, continued and by mid-July, 8 of the 11 large pools in the mile of stream designated as station 1 were completely filled. The three remaining pools were partially filled. This naturally resulted in a movement of adult bass and a concentration of fish in the remaining pools. The total number of bass in this area, however, was much less than on May first. By mid-July 1949 there were no large pools in this area and most of the 28 adult bass counted on May 4 during the spawning period were no longer in the area. At this time 6 nests were also observed in the mile of stream investigated.

From Project 38 of the Iowa Cooperative Fishery Research Unit sponsored by the Iowa State Conservation Commission and the Industrial Science Research Institute of Iowa State College.

A similar pattern of events occured in Lamont Creek near Dundee in Delaware County. The 3 miles of stream immediately above the creek mouth on the Maqucketa River were investigated. When first visited on August 14, 1947 there were three concentrations of adult smallmouth in this area. Two were in pools formed by beaver dams and the other concentration was in a large pool above a natural dam of limestone rubble. Observations on March 12, 1948 indicated that dam No. 2, 100 yards upstream from the creek mouth, had been washed out during the fall or winter and rebuilt. Dam No. 1, some 2 1/2 miles upstream, was being rebuilt at that time. During the summer of 1948 no large adult bass were observed in the 3 mile study area but yearling bass were common. According to residents near the stream the dams remained intact during the winter of 1948-49. Observations during April and May 1949 revealed no large adult bass in the mile of stream immediately below dam No. 1. On May 4 10 nests and 25 young adult bass were observed in this mile of stream. Four of the 10 nests were within 75 feet of the upstream side of a new beaver dam. There were no nests in pools immediately below the dam. Moreover on the same date in the 1/2 mile section of stream above dam No. 1, 7 nests and 18 large adult bass were observed. These bass had evidently moved down stream to spawn.

During 1948 and 1949 larger streams, more suitable for smallmouth, were investigated. The Volga River, Crane Creek, and Little Turkey Rivers in Fayette County were the streams studied intensively. Observation prior to the spawning period revealed no discernable migration although many bass were in evidence in the deeper pools.

During the spawning season from May 1 to 15, 1949, counts of nests and adult bass were made on a representative one mile reach of each stream. The Volga River near Fayette, Iowa had the highest counts with 38 nests and 87 adult bass per mile. The Little Turkey River, south of Waucoma, had counts of 28 nests and 72 adult bass per mile and Crane Creek, east of Alpha, had 26 nests and 67 adult bass per mile. The distinct concentration of nest sites at the margins of pools where concentrations of bass had been in evidence for one month and the relatively few nests in areas not previously occupied seemed to indicate a minimum of movement associated with the actual spawning. If any appreciable movement (which might be termed a migration) did occur, it evidently was completed prior to April 5th.

In addition to the spawning dispersal there seemed to be a post-spawning period of movement during which small shallow pools with adequate shelter were occupied. During the summer as the water level fell, many of these shallower pools were again deserted and by mid-July in 1948 and 1949 the smallmouth were often associated in schools, particularly during mid-day. This period of schooling lasted well in September in 1948 but was abruptly ended about August 15, 1949. Definite schools of smallmouth were rarely observed after August 14, 1949 and the bass were

concentrated in the deeper portions of the pools. This change coincided with a distinct change in temperature. Thermometer readings as low as 37°F. were recorded for the night of August 14-15 in northeast Iowa. A succession of cool, cloudy, windy days and cool nights lowered the water temperature in the upper Volga River from 80°F. to 68°F. by August 18.

A tagging program was conducted during 1948 and 1949 and a total of 240 near legal and legal size (10 inch T.L.) bass was tagged. Of 15 fish tagged in the 3 streams and recaptured within the year of tagging, 13 were retaken in the same pool in which they were caught, tagged, and released. Six of eight bass recaptured after overwintering were again captured in the same pool in which they were originally caught. One of 7 smallmouth bass tagged in Coffin Creek in July 1948 was recaptured a year later in the Maquoketa River. All three fish that had moved an appreciable distance displayed the same pattern of movement, a downstream drift followed by an upstream journey.

An electric shocking device was used to substantiate the observation that smallmouth do not overwinter in the shallow pools in which they reside during the summer. In shallow pools, where 21 bass had been tagged and released during the summer, only one small adult untagged smallmouth was captured. Only one other adult bass was observed by the crew conducting the shocking. The two adult bass observed were in the deepest pool investigated with a maximum depth of about 5 feet.

We may conclude from the above results and observations that the smallmouth moves to the extent of satisfying his individual needs and instincts, moving into smaller streams to spawn when conditions are unfavorable for spawning in the large streams and moving only enough during the summer to find food and shelter. This movement, in the small streams, may become a downstream drift to larger pools and larger streams. Smallmouth that spend the summer in shallow pools move to deeper pools to spend the winter.

Water levels and pool space and depth seem to be the chief factors affecting the movement of smallmouth in the streams of northeastern Iowa. Temperature and other climatological factors may also affect smallmouth movement.

Madison 2, Wisconsin
May 1, 1950

MEMORANDUM FROM: WISCONSIN CONSERVATION DEPARTMENT

SUBJECT: Papers Presented at the Eleventh Midwest Wildlife Conference

In accordance with the procedure that has been carried on through the years, we are making available to you copies of the various papers presented at the Eleventh Midwest Wildlife Conference. You will recall that the turning in of papers for processing was optional with the individual presenting the paper and not all papers were submitted to us for mimeographing and distribution.

The following papers were not submitted. You may identify these papers, by number, by referring to the corresponding numbers in the program for this Conference, and it is suggested that you contact the authors direct for a copy of a particular paper that is not available through this department.

Nos. 10, 21, 34, 37, 38, 40, 45, 51, and 54

The papers you requested by either leaving the check-off list or by letter are attached.

FRZ:jcc

POUNDING THE CONSERVATION STORY HOME

Arthur H. Carhart
Denver, Colorado

Presented at the 11th Midwest Wildlife Conference on
December 15-16-17, 1949, Madison, Wisconsin

During the past two years as I have attended conservation and wildlife meetings, I've heard wailing in the hotel corridors. Sometimes it was solo crying and sometimes a sobbing chorus. The melody was the same; the conservationists complained bitterly about the paucity of publicity. The meetings certainly did not get the press they merited; for reasons not too obscure.

In September of 1948, one of the most significant meetings of our time, the Inter-American Conference on Renewable Natural Resources, was staged in Denver. Local newspapers, press associations and radio officials were forewarned. The subjects covered were vital to the nations of the Americans and just people.

One press association assigned a local staff man to the conference. He dwaddled around the press room for two days, then scrammed. You couldn't locate a staff representative of any paper with radar or by rattling a cocktail shaker. About that time national press wire services began to receive rush cablegrams from Buenas Aires, Rio and other South American cities, asking why news of the conference wasn't coming through. They knew it was important. Forthwith, the headquarters of the first wire service mentioned put a bewildered newsman on a plane, raced him to Denver from Washington, and threw him into the tail end of the week long conference. He followed the uncertain trail of his local associate for a day or so, sensed no news significance in talks by men from twenty-two western hemisphere nations who were discussing the survival of the human race. So - he checked out, still in a state of bewilderment. That conference got deficient press coverage.

I was standing in a group of outdoor writers in the corridor of the Statler Hotel in Washington last March as the National Wildlife Conference was in session. One of the most prominent fellows working in this outdoor writing field suddenly blew a gasket. He was there to get raw material about wildlife conservation for his tens of thousands of readers ---- and he was frustrated. He knew the stories were there but the big shots were talking way over his head.

There are always stories in the wildlife and general conservation fields, that are arresting, informative and vital to every living person. There's something very wrong when all avenues of public information have to be practically dynamited to carry even a re-write story on the back page.

One of the first stoppers to getting the main story across lies in monumental confusion of what is meant by conservation. What we know as leadership in this field is mainly responsible for that confusion.

Across the nation there are hundreds of organizations putting out their version of what conservation is and what should be done to achieve its goals. We have the specialized technical groups such as societies of mamologists, foresters, ecologists and bio-agronomists. At the other end of the spread there are conservation committees in American Legion posts, garden and women's clubs, chambers of commerce and the Possum Creek Rod and Gun Club. Each has its concept of what conservation is and propounds it. Almost universally the

interest of any such group is in some segment of the whole field, and with worthy zeal and good intentions, their story is ballyhooed ahead of the primary things which are the basis of sound conservation in all phases. The result is, that each side-show makes its pitch, gathers its own audience and the main show in the big-top never gets pulled together and put across.

What is needed clear across the whole field is a universal credo in conservation. If then, having pounded on this fundamental creed until it is understood, any group wishes to base its catechisms and rituals on that and propound them, that would be all right. For the convert to conservation could then go on to his labors in some segmentary section of the whole with far greater understanding and effectiveness.

The specialist is so saturated with understanding of what is involved in conservation he believes any moron should know the fundamentals. What's more, because he takes this for granted and begins to propound his own particular sermons in the jargon of the trade. He adds bewilderment to confusion. You don't have to talk down to the public but you have to speak English. Doing so is no sin and it isn't painful.

I have a simple, universal conservation credo to suggest. It can be stated in two sentences. Here they are:

All life depends on the green cell.

The critical zone in conservation is a foot or so below the soil surface and a couple of feet above it.

No extension of the conservation program can go anywhere without accepting the verity of those two statements. They are fundamentals that any intelligent person can grasp. They are the inclusive area in which every group or individual working in conservation can find a common cause. Starting from this point any elaboration, any direction, becomes understandable.

If some fundamental concept of the conservation program were put forward by every conservation group in the nation, and pounded and pounded, until the citizenry realized their life depended on acceptance and action in relation to this credo, we'd have a unified force driving toward genuine conservation that would lay a solid foundation under every portion of every extension of the whole.

In order to lay such a foundation, there must be a central clearing agency, a strategic headquarters if you want to call it that, which will correlate all efforts of these groups now plugging special interests. There must be the facility to relate their efforts to driving home to all people the fundamentals. Putting it another way, we now have a lot of cogs in conservation, each turning merrily in its own orbit, but all lacking an efficient and effective central gear which would relate all their efforts into one intergrated machine. If such could be brought about, if the clear and understandable basic credo could be recognized by all groups, if their efforts in pounding out the fundamentals of this gospel could be combined, this conservation story would begin to go over immediately.

Those interested in the wildlife field, particularly those who are engaged in management of this resource, have a special opportunity to carry the conservation story to a vast audience. Hunting and fishing are a direct, personal tie between twenty to thirty million citizens, and outdoor America. Those who are

professionals or semi-pros in the field, certainly have tried to make base hits and home runs in getting their story across. But so far there have been too many strike-outs, pop flies and clumsy bobbles.

Let's look at what may cause fumbling in trying to get the story over to the public and how the fumbles might be eliminated.

Right at the foot of all problems in projecting any part of the conservation story lies the extended specialization of the fellow who knows most about it. I'm speaking of the technical worker. Too often he is so soggy with the scientific significance of his findings he never grasps the leaping drama in the story he has to tell. He insists on getting his data before the public. Scientific accuracy and insistence that the story be presented as a technical report fouls up any chance of putting in the dramatic punch. If a sweating reporter tries to get at the nub of the story so he can present it to readers in a way which will drive home the significance, the reporter probably muffs the dynamic feature that is in every wildlife study or project. Then your scientist yowls about being misquoted, and how the newsman misrepresented. The rare fellow who can disentangle himself from his statistics and charts, and with ultra-sound scientific background, slam through the dramatized story, is a prizewinner --- for himself and all conservation. There are a few of such scientific fellows, and they hit bulls-eyes with their writings.

I had twenty or so technically trained conservationists on my staff during the years I organized and directed the wildlife restoration program in Colorado. The field data they delivered were excellent. But how many of that twenty do you supoose could write a report that would make sense when a commission member read it? One, maybe two could do it. Sometimes I had to strain my brain to know just what they were trying to say --- and I knew what they were trying to say.

It may be important as Sheol for a technical man to be able to write a paper for some scientific journal so filled with trade jargon he half-bewilders his fellow researchers. He may bemaze them even if he doesn't amaze them. It is far more important that somewhere in his training, he will secure an outlook which will enable him to project to just ordinary people, the simple significance of his work and where it is pointing--or at least to be able to direct a writing man toward the nub of the matter and how it is newsworthy.

There's too gosh hang it much stress placed on that deadly dry munification of English we call technical journalism, by too many schools.

The average writer who might get assigned to produce a story based on some phase of wildlife conservation is even less prepared to handle the job than is the pure science brother. He gets material dealing with some detailed extension of conservation thrown at him, and he hasn't even a smidgin of groundwork in understanding of fundamentals to assist in his interpretation. I can cite the bewilderment of the several reporters tossed into the middle of the Inter-American conferences as a typical demonstration.

Iowa State College is offering a course in outdoor writing. Other schools are setting up the opportunity for future preachers of our gospel to have the foundation knowledge to interpret the conservation facts in a dramatic, but wholly factual, way. We have notable individuals, newspaper columnists and magazine writers, who have sensed the significance of conservation in their

material, and as they pound out the readable, attention-gripping stuff, they persistently hook the significance of the current story to the realities of our situation in conservation.

Therefore, one of the basic deficiencies in the mechanisms of putting out the conservation story is writers who can write and are at the same time adequately grounded in what we call conservation. There's a really sizeable gap to be filled.

If we had a corps of such men, we still have existing barriers to their getting through with their message to the big public. One of the largest morasses to be traversed, is indifference in varying degrees, among those who direct the policies of the media of information --- magazines, newspapers, radio, motion pictures.

In recent years, our major outdoor magazines have given far more space to conservation themes than was the case a decade ago. I know most of the fellows who sit in the pivotal editorial positions on these publications. They're swell gents and they're top-flight editors or they couldn't hold their positions. Most of them have come up from the publishing side of the business. That's of prime importance. All, I'm ready to swear, are the very essence of what we would call genuine sportsmen. I suspect they're allergic to conservation articles. They probably have had deadly dry and seriously stuffy texts from highly technical scribes that has caused the allergy.

There's a real obligation on the part of our outdoor magazines to tell the conservation story. Their position of leadership carries that obligation. The future of the magazines themselves, the business of their principal advertisers, rests squarely on the maintenance and development of adequate wildlife to support the hunting and fishing sports. But it's like trying to break into the First National sometimes to get conservation material in these magazines.

Just to illustrate, I recently queried an editor friend about an article concerning one of the currently most significant studies relating to maintaining trout fishing. That study not only is significant in itself but it promised to set a pattern for maintaining trout resources across the continent. It should be told. I briefed it for the editor. He said it sounded stuffy and heavy. I didn't write it.

Undoubtably one of the reasons our outdoor editors don't carry more of the conservation story, particularly in its basic phases, is because of the deficiencies of writers to adequately dramatize that story --- and I'm probably one of the writers lacking that ability.

I do believe, honestly, that the readership of our outdoor magazines are ten jumps ahead of the conservation thinking of most editorial directors in that field. I may be wrong about that, but I know I'm not wrong in declaring that the future of those publications and of their advertisers lies in far greater projection of the conservation idea and the sound practice of the idea in a nation-wide program, and that there is a genuine responsibility in our outdoor periodicals to project the conservation story, interestingly, dramatically and constantly.

If you want to encounter a monumental bog of indifference and outright ignorance about the vitalness of conservation, turn to the newspapers.

Particularly have a look at the paucity of space they give to the hunting and fishing sports and wildlife management on which these rest. There are blazing exceptions to this --- and where they occur you'll find an outdoor writer who knows his stuff, all angles.

But for the most part, you can pick up any metropolitan sheet, daily or Sunday edition, find three pages filled with hockey, junior college basketball and who won the third race at Bowie. Two columns may spread the story of an outfielder who has a charley-horse or the resignation of some assistant coach at a jerk-water junior college. But hunt for the outdoor stuff. You'll have to hunt.

There is no thought of declaring a conflict between hunting and fishing and the stadium sports. The rightful place and interest value of the spectator sports is wholly conceded. What I am emphasizing to the full, is the apparent ignorance on the part of newspaper publishers regarding the standing of hunting and fishing in the sports field.

There are near to thirty million actual players in hunting and fishing. Many surveys show approximately seven out of ten adults in a community hunt and fish. The outdoorsmen spend an estimated four billion dollars a year as they "play" their game which is between six and eight times the amount paid in at the gate for all spectator sports.

A million dollar boxing match gate gets front page headlines. The fact that sportsmen put out about an average of three times that amount every day in the year never has sunk into the newsprint mind.

Sport staff writers on newspapers are recruited from ranks of those who have been somewhat notable performers on the old college team. They write, and they promote, the activities they know. They're able writers on their subjects.

We simply must face the fact that sheer accretion, compounded by the average sports writer, has fixed the idea in editorial minds that sports mean baseball, basketball, and so on, to grunt-and-groan wrestling. Hunting and fishing simply are outside the pale.

Again we come back to that factor of lack in writers who are both that in fact and know their outdoors from grass-roots conservation to the technics of hunting and fishing.

If it were possible to have someone sit down with the head men of a dozen leading newspapers, and in simple language, pound home the picture of the relative status and reader interest in hunting and fishing, the intelligent editors would see a great bet being missed. Even if our sportsmen began an insistent demand that their sports be given commensurate space in news columns results would show up.

The writers then who might produce material for what would be a far more sensible and reasonable allocation of sports page space to hunting and fishing, could not preach conservation in the abstract or theoretical sense. But they could and they would carry the responsibility of interpreting, and linking in, the relationship of conservation factors and objectives which would be inherent in any news story they might print. The able outdoor writer can make high drama,

gripping interest, out of the vast majority of all the studies and projects embraced in wildlife management but he can dramatize conservation as a part of his stories.

If possible, the radio is farm more ignorant of the potential listener interest in the outdoor sports than are newsmen. There is one national radio program on hunting and fishing which shows up for a half-hour per week. It's anything but hot; both in content and presentation. It is more like the reading of an encyclopedia than anything else. It has no breath of life. Its unfortunate shortcomings with not too much listener response has made radio people coy about any other programs in this field.

But radio has an hour's show where yelling reporters give jittery accounts of third rate boxing matches against the background of a couple thousand booing customers. Your own favorite radio station probably has several quarter hour periods per day of "sports casts" and you don't hear any recognizable recognition of the two greatest sports of all. You hear about ball scores here, coaches there, and personality sketches of more or less sports greats. The top brass in radio needs the same gentle but firm exposure to the facts of life about the position of hunting and fishing that should be given newsmen.

The national general magazines are just as lacking in dealing with the two greatest sports. They print several pieces per year regarding several of the spectator sports but do well if they have one on hunting and fishing. If they present problems of conservation, it is against an economic and social background --- which is good enough for any forwarding of the cause benefits all phases. But they do seem to have in their editorial offices, no appreciation whatever of the status of hunting, fishing and wildlife in the interests of thirty million or more Americans.

There is no greater muffing of the ball in telling the conservation story so it will stick and grow, than in the sports program of our schools. The schools try to teach conservation, out of text books, in an academic manner. All the while, in hunting and fishing which might and should be a part of every school's program, there is the widest open doorway through which scholars could pass and find a direct, personal interest in all the outdoors. Give kids half a chance and they'll grab at the know-how of all sports afield.

In hunting and fishing we have not only an avenue for leading youngsters into the direct contact with the outdoors and understanding of the living world, but sports which can be undertaken by every kid in school, boy or girl, puny or husky. Whereas game sports teach cooperation, fishing and hunting teach self-reliance. An athlete doesn't follow his game sport many years beyond school, but he may fish and hunt so long as he can leg it to field or stream. Dad would be somewhat ridiculous joining in a kid's football game, but he's full partner and team-mate with his teenager if they go hunting and fishing together. Perhaps one of the most important features of all if the schools were to give instruction in outdoor sports would be the ingraining of real sportsmanship in coming generations. If anywhere near the emphasis were placed on sound sportsmanship in hunting and fishing that is put on it in game play, we'd have fewer game hogs and poachers, and far fewer hunting accidents in the future.

The answer to the school phase of using hunting and fishing as a vehicle for carrying the conservation story is rather simple. All that has to be done is convince the school officials that there is gross neglect in regard to these

sports, their value in conservation education, their worth in teaching self-reliance, their continuing value beyond the school years. Perhaps this is the most potent point of the whole scene, where hunting and fishing may be gripping, living media for carrying out the conservation story and giving every individual the personal touch that must exist if he is to grow into an active conservationist.

In the broad field, there is the lack of one central, dominant thesis or credo which everyone can understand, and which every worker can preach as gospel. There is a glaring lack of one central campaign headquarters to get all the troops of the conservation army working together in one fundamental plan of unified strategy.

In the wildlife field we have one of the most potent doorways through which millions may be led to take a personal interest and personal action in forwarding conservation. This field lies fallow.

I have tried to indicate here, why the wildlife story and its conservation features, along with the whole story of the entire field, has not flowed out through some major potential outlets to reach the multitude. Like a fallow field, all that must be done is to plant good seeds in the right place, and cultivate them, and the crop will mature.

The conservation story, all of its phases, wildlife especially, is a gripping, dramatic thing, carrying tremendous impact on the life of every individual and the nation. When it is so presented, simply, dynamically, powerfully, the story will be told and the people will listen and understand. It's our job to tell the story.

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DEVELOPMENTS IN FISHERY BIOLOGY

by

Karl F. Lagler

Prepared for the Eleventh Midwest Wildlife Conference

Madison, December 16, 1949

Work in fishery biology is advancing at a rate and on a scope that would hardly have been deemed possible twenty-five years ago. Great forward strides along with certain retrograde advances, have been made in recent years. Progress today is built upon half a century of work under the Fisheries Research Board of Canada, on three-quarters of a century of effort by the U. S. Bureau of Fisheries and its successor, the U. S. Fish and Wildlife Service, as well as upon the work of individual local and foreign colleagues. Active fishery research and management by state, provincial, collegiate and private fishery organizations have been under way mostly for lesser periods of time. Our present considerations of developments in the field are considerably enhanced when one reflects on the pertinent historical background.

For convenience in reviewing current developments, I have classified them as ones of general significance and ones primarily of technical or administrative importance for the northcentral area of the continent. It must be recognized, however, that many of the latter, though local in origin or pursuit deal with matters of very wide concern.

GENERAL DEVELOPMENTS

1. Dingell-Johnson Bill. Veto of the Dingell-Johnson Bill by the President of the United States was an unfortunate development for the fisheries. In this bill the Congress sought to divert the income of the present ten per cent excise tax on fishing tackle from the general fund of the U. S. Treasury to the states for fishery work. The bill paralleled the eminently successful Pittman-Robertson act. At the present moment, interested groups (e.g., Izaak Walton League of America) are working to have the bill passed again, over the President's veto if necessary. See that you are active in one of these groups! It means a substantial annual amount, perhaps between four and five million dollars, for fishery work.

2. Sport Fishing Institute. On October 4, 1949, a Sport Fishing Institute was incorporated in Washington, D. C. This nonprofit organization is the fishery counterpart of the Wildlife Management Institute. You may criticize its name, yet it may be singularly fortunate that it does not include the word "management" because of the present state of management knowledge and practice.

This organization has its inception in a national manufacturers association, The Associated Fishing Tackle Manufacturers. The board of directors is at

present drawn entirely from this group. Voting memberships are also currently available only to members of the Association. Contributing memberships are open to others, however, at a minimum of fifty dollars per year, with charter privileges to June, 1950.

The objectives of the corporation follow as abstracted from the by-laws:

(1) To promote and assist in the conservation, development and wise utilization of our national, recreational fishery resources.

(2) To advance and encourage the development and application of all branches of fishery research and management.

(3) To collect, evaluate and publish all information of value to advance fishery science and the sport of fishing.

(4) To assist existing educational institutions in the training of personnel in fishery science and management.

(5) To encourage a wider participation in sport fishing through the distribution of information pertaining to its health and recreational values.

(6) To assist and encourage cooperate effort between all existing conservation organizations.

The Sport Fishing Institute is at present negotiating for a director whose knowledge of the field and whose reputation are outstanding. The formation of the SFI is timely and its future role may be one of greatest importance.

3. Better Fishing Incorporated. With the formation of the SFI, the Associated Fishing Tackle Manufacturers withdrew its support from Better Fishing Incorporated of Chicago. The latter continues as the prime exponent of fishing for children. It is the promoter of the fishing rodeos which vote-conscious mayors now so ardently sponsor in thousands of municipalities each year. State fishery offices carry much of the burden of these shows since they are obliged to provide the fish for the youngsters to catch. Surely it is a fine thing to learn the principles of sport fishing early. It remains a question if the sport of fishing can be truly sensed in a heavily stocked playground pool. It is possible that thought should be given to this matter and that city governments should be informed of your policy before they are brought to a high pitch of enthusiasm by BFI. Perhaps we should all learn to fish, but to fish for fun in the wild. If initial interest is aroused in a plastered park pond, disappointment on natural waters later may destroy the desire to fish or may increase the number of complaints a fishery official has to handle.

4. National Fisherman's Week. Some will view with alarm the designation of a spring period again this year as National Fisherman's Week, continuing a custom of the past few years. You probably see it now, screaming from the windows of hardware and sporting goods stores and from pages of the outdoor magazines and newspapers. Do not be overly concerned, however, for it is not another fishing rodeo or most- or biggest-fish contest. It is merely the attempt of a trade journal (Sporting Goods Dealer) to get dealers to use

attractively the display materials furnished to them by manufacturers. The award is a cash prize and an all-expenses-paid week of fishing for the winning dealer. Guess where? --in Minnesota, no less! And the governor even shakes hands with the lucky man. Oh yes, Minnesota also appropriates a couple hundred dollars a year to help the winner of National Fisherman's Week enjoy his vacation in gopher land.

5. Publicizing the use of rotenone. The eradication of fish populations for experimental purposes has become a common practice in the last decade and has probably reached a peak in 1949 for the period. Like the story of aging fish by scales, it remains ever new for the layman. It is a glamorous operation, somewhat unique among fishery techniques, and has obvious news value. Since presently known chemical tests for the detection of rotenone and related toxicants are arduous and since great damage may be done to fish populations by these agents, especially in streams, concern continues over how much information on such poisons and their use shall be issued to the public. There are certain particular problems in this connection; at least in some states, ordinary persons may use it within existing laws. It would seem best that states and provincial fishery workers examine the statutes of their areas in order to learn exactly what the local situation is in this regard. If necessary, assistance might be given to legislators in drafting an adequate legal code.

A simple law is that of New York (Section 213) where it is illegal to put any poisonous substance in waters in quantities injurious to fish life. Even in presence of adequate litigation, modesty of output on the subject for public consumption probably should prevail. Perhaps another angle of public relations should also be considered; it may be best to adopt the terms "chemical treatment" or "chemical eradication" rather than "poisoning". Some humans are very sensitive about such things; "poison" has a sinister meaning to them.

6. Publicizing the use of electricity for shocking fish. Similar to the problems revolving about publicity on rotenone, are those on shocking fish. Again, shocking is a much easier and surer way of getting fish than that which most anglers employ. In addition, like rotenone, it is a glamorous tool. Perhaps danger to humans should be mentioned pointedly in all materials released. Does your state or province outlaw electricity as a means of fishing?

DEVELOPMENTS IN THE NORTHCENTRAL AREA

1. Fish propagation and stocking. Culminating recent years of evolution in practice, there is now a much closer integration of stocking with management. The propagation and planting panfishes for population maintenance is essentially discontinued. Stream trout are largely stocked at sizes legal for the creel. Planting of commercial species as fry in Great Lakes waters is curtailed (abandoned completely by the U. S. F. W. S. and various states; continued by Ohio). Walleyes are being reared successfully to the fingerling stage (e.g., Wis., Ont.), as are whitefish (Ont.). Pondfish propagation has swung largely to the basses concommitant with discontinuance of sunfish culture. Many warm-water fish rearing ponds have become experimental waters for production studies and species combination analyses. Experimental production of two kinds of hybrid sunfishes and tests of their presumed sterility have been or are being made (Ind., A. F. T. M. in Michigan and Illinois).

There continues an enlivened evaluation of stocking various fishes; in certain instances these studies are on a long term basis. Most often the plan is one which couples alternation of years of planting and of no stocking with yield studies. Species under particular investigation are: Atlantic salmon (L. Ontario tributaries, Ont.); lake trout (U. S. F. W. S. and cooperating lake states); walleye (Ia.); whitefish (Bay of Quinte, Ont.); largemouth bass (e.g., Minn.; A. F. T. W. in Mich.; Ill.).

Whereas "stocking plans" were once the vogue, now emphasis is on characterization of waters not to be stocked. In the Wisconsin Fish Policy, for example, it is indicated that management through continued stocking is not to be practiced when any of the following conditions exist:

1. Biological
   - A. High population of predatory or exotic species
   - B. High population of stunted fish
   - C. Insufficient forage present and light fishing intensity
   - D. Poor angling results after years of continuous stocking

2. Physical and chemical
   - A. Very soft water (less than 10 p.p.m. of bound CO_2)
   - B. Annual winter-kill lakes
   - C. Small lakes
     - (1) below 30 acres for walleyes and muskellunge
     - (2) below 30 acres for largemouth bass, smallmouth bass and panfish
   - D. Lack of suitable spawning grounds for certain species
   - E. Summer temperatures too high for trout

3. Human
   - A. Inaccessibility
     - (1) private waters
     - (2) waters not accessible by road for planting or angling
   - B. Very light fishing intensity
   - C. Pollution

It is generally felt that stocking retains an important role in fish management but that, owing to the high costs of artificial propagation, planting now must be done only where present or future fishing success is evidently dependent upon it.

2. Fishing regulations. The tendency toward liberalized regulations which has marked recent years continues (Michigan, Indiana). The biological basis of this trend lies in the now well-known high reproductive potential of such species as the sunfishes and perch. It is hoped that increased catches resulting from reduction or removal of size, creel, and season limits may substitute for natural predation in checking populations which would otherwise stunt. It is generally conceded that the success of selective angling for the more predacious game species has favored overpopulation in panfish species.

On the other hand, increased stringency in size limits is appearing for trout. Effect of raising legal length from 7 to 10 inches is a subject of experimentation (e.g., Michigan). It is thought that this elevation will increase the poundage of production, spread the fun of fishing, and perhaps make stocked trout more wary as they increase from a stocked length of about 7 inches to the new legal length.

There are indications that a length limit of 10 inches and a bag limit of 10 fish contribute nothing toward the maintenance of good bass populations and adjustment seems in order for small artificial lakes (Ill.).

Restriction of fishing is indicated for a number of trout lakes subjected to unusually heavy rod pressure resulting from airplane transport of anglers (Algonquin Park, Ont.). It is proposed that about half of the 150 some lakes concerned be closed to fishing in odd numbered years while the other half are open, and vice versa. Prerequisite to this plan, of course, is that the lake be unsettled and publicly owned. Application of the principle of alternating closed seasons is hardly tenable for resort waters. Nevertheless, the results of the plan, if followed, will be extremely interesting.

Continuing problems of commercial fisheries in relation to sport fisheries may call for additional changes in laws. Parts of one large river system (White R., Ind.) were opened to commercial fishing by the state legislature, without support of the conservation department. Waters where coarse fish removal is pursued, also fall into this category, particularly since it appears desirable that such fish be systematically cropped to avoid waste, if for no other reason (e.g., Minn., Wis.).

4. Productivity, fish populations, and yields. Of universal current concern to fishery biologists are a diversity of problems on biological productivity culminating in yield of fishes to commercial or sport fishermen. The diversity of problems manifest themselves in the several researches now underway. Since the scope of this work is at once so large and so important, it is perhaps to be regretted that there is not better integration of effort among the several units concerned. The over-all aims are: (1) to work out the mechanics of biological productivity of inland waters; (2) to determine the population levels of preferred fish species necessary to give satisfactory angling or profitable commercial fishing; (3) to regulate both producing and harvesting forces to secure the traditional aim of maximum sustained yields.

Work on the most fundamental of these problems of productivity is difficult for fishery administrators to justify to the holders of purse strings. The projects almost of necessity must be long term ones. They are expensive to conduct and results from them are usually not dramatic. By and large, one might characterize the method of fish management in 1949 as being of the shotgun or trial and error variety; systematic approaches to the elements of fish production are few in comparison.

A few encouraging signs of change are with us, however. Ontario has a new laboratory of experimental limnology, now almost completed, with an elaborate field and laboratory program under a competent staff. An outstanding feature of the lab is its large "artificial lake". This is in the form of a deep, cylindrical, indoor tank, in which various conditions of natural waters may be set up and tested. Quebec also has a new program on basic productivity at its Mont Tremblant Biological Station now less than a year old. The view of M. Prevost who is responsible for the formation of this station is so remarkable and such a model one that I must repeat it to you: "We are not expecting practical results within the next ten years". Both of these new laboratories are importantly concerned, among other things, with the basic mineralization process. Work on fundamental factors responsible for yields also continues for Lake Erie in the Ohio laboratories at Put-in Bay. During

the past year Michigan established a second trout experiment station at which special emphasis will be given to species relationships in production among brook, brown and rainbow trout. Ricker in Indiana continues to probe the mechanics of survival in terms of recruitment and mortality rates in relation to fish yield.

Decline in yield of lake trout and evident increase of the sea lampry in the upper Great Lakes finally stimulated congressional action to permit the expansion of the Great Lakes Investigations of the U. S. F. W. S. Administrative changes have already taken place in the investigations to prepare for augmented activity and biological posts are being filled currently. It is hoped that at last work may be done on many phases of the productivity of the Great Lakes, for it is realized that the sea lamprey is only one of a host of factors, and perhaps an overevident one, in an extremely complicated series of events affecting the harvest of these inland seas by commercial fishermen.

Creel censuses are widely operative today. The modern trend, however, is away from the general types of census and toward a type which is associated with population studies of fish. The approach is toward the problem of how many fish produce what quality of angling. Beginning attempts have been made to place the sampling methods of creel census on an efficient and statistically sound basis. Henry Predmore of Michigan, a progressive worker and thinker in these matters, regrettably passed away during the year. IBM machines have now been used to speed the handling of extensive data.

Current population studies, for the most part, employ the Schnabel method although that of De Lury is also in use. A test netting program aimed at disclosing relative population densities rather than actual numbers is operative in Ohio.

5. Environmental improvement. Once upon a time there was a fishery bandwagon called "stocking". The wheels came off and let both technicians and administrators down. Now there is a new wagon: environmental improvement. The latter includes a wide assortment of physical, chemical and biological changes of fish surroundings. It also encompasses various kinds of population manipulations of fishes themselves. A hasty appraisal of work in this field indicates that it holds great promise for fish production. However, some parts of this new wagon are being built in the dark, much like was its unfortunate predecessor. Adequately planned and tested improvements are the exception; regrettably, most current ones are shot-in-the-arm, trial and error tactics. At present, there is a crying lack of before, during, and after studies for many of the environmental changes wrought. This circumstance may have arisen because of the suddenness in the shift from stocking to its successor. However, unless definite steps are taken, too great a superstructure of hopes will have been built while producing only a fraction of the desired results. Let's take the guesswork out of environmental improvement.

6. Miscellaneous (but still important). Limits of time now force me to treat very briefly a number of other current developments and to omit others. The "regional biologist" idea remains popular, with many states breaking initial large regions into smaller ones (e.g., Wis.). Administrators contine to be harrassed with the problems of what researches to pursue from among the welter of trouble-shooting requests which they receive. In some areas, acquisition

of lands to assure future fishing privileges to the public is being furthered. In the southern part of the region (e.g., Mo.), farm ponds are still on the increase. There is still no agreement as to optimum species combinations, numbers to plant, and cropping schedules for small northern waters. The creditable lake-per-county program for Illinois is temporarily abandoned because of the high cost of government. In the educational world, both fishery research and training will benefit from the establishment of the new Department of Conservation at the New York State College of Agriculture of Cornell University.

SIGNIFICANCE OF DEVELOPMENTS

Fishery biology is progressing both as a science and as an art. Various aspects of progress are not on equally sound ground. Viewed from the vantage of previous history, workers should not be overly influenced in their thinking by past policies and practice. They should climb on no management bandwagon. Policies should be flexible and should be backed with research programs designed to evaluate them.

An aim at team research on fundamentals should be made. Some consideration seems in order for integrated conference investigations of certain key factors of productivity, as well as on the efficacy of certain management techniques (existing examples: Upper Mississippi survey; sea lamprey investigations; lake trout investigations).

Work in conservation education should be extended to gain additional public confidence and to give investigators better perspectives on their work.

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Wisconsin Conservation Department
Madison 2, Wisconsin

Division of Fish Management

Section of Fishery Biology
Investigational Report No. 714

The Effect of Perch Removal on a Small Northeastern Wisconsin Lake

by
Warren Churchill

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The Effect of Perch Removal on a Small Northeastern Wisconsin Lake

The problem of stunted fish population is widespread in Northeastern Wisconsin. In this region there are thousands of small landlocked glacial lakes of 40 acres or less. The water in these lakes is very soft and productivity is low. Results of poisoning projects indicate that such lakes will support a total population of 50 to 100 pounds of fish per acre.

Increasing the productivity by fertilization is theoretically possible, but not practical. The best that can be done is to manage the small population available so as to produce "catchable" fish.

Species commonly found in these lakes are largemouth bass, bluegill, perch and bullheads in any combination and sometimes sunfish and rockbass. All of these are very efficient at reproduction. Counts made in Punch lake showed as many as 6,000 largemouth bass fry produced in one nest, with an average of about 3,000 and a total production in a good year of about 15,000 per acre. Counts of fry in bluegill nests in Day lake run as high as 22,000 per nest. The usual problem in these small lakes is therefore one of overpopulation, with the available carrying capacity divided among too many individuals. Fishing may aggravate this tendency by removing the larger fish needed to control the young.

A number of experimental management projects are now being carried out by the Wisconsin conservation department. These include introduction of large predators, total and partial poisoning, removal of size and bag limits, and removal with nets. This paper is concerned with the results of removal of perch by netting.

Curtis lake is located in Oneida county five miles west of Woodruff on State Highway 70, in Township 39 North, Range 6 East, Sections 8 and 9. It is landlocked with an area of 22 acres and a shoreline of 0.86 miles. The maximum depth is 18 feet and the average depth is about 10 feet. The bottom is mud with very little vegetation. The south shore is formed by the highway, west is swamp and the north and east shores are high ground with pine and birch except in cleared areas. Chemical characteristics are given in Table I.

Table I
Chemistry of Curtis Lake

	7-31-27	7-7-29	7-28-36	4-23-46
Depth	0	0	0	0
Temperature	23.4	22.0		
Free CO_2 ppm.	2.3	2.5		
Alkalinity ppm.	1.48	1.14	1.36	3.8
pH.	6.2	5.9	5.6	
O_2 ppm.	14.3	7.3		
Nitrogen:-				
NH_3 ppm.	0.01			0.02
Organic ppm.	0.73			0.29
NO_2 ppm.	tr.			
NO_3 ppm.	0.0035	0.010		
Total P ppm.	.033	.013		0.015
Sol. P ppm.	0.007	tr.		0.015
Chloride ppm.	1.10	0.75		0.0
Residue ppm.	12.53	14.83		
Fe ppm.			0.08	
Ca ppm.			1.6	
Mg ppm.			0.7	

Perch are the dominant species, with a large number of bullheads, some large-mouth bass, a few suckers.

Curtis lake was once a good bass lake. In 1939, complaints of deterioration in the fishing led to an investigation. Test netting revealed stunting of both bass and perch and a reduction of population was recommended. In 1940, 175 muskellunge x northern pike hybrid fingerling were stocked, together with 500,000 sucker fry to support the hybrids until they were large enough to begin predation on the species present. Survival of these fingerling was poor. There have been a few reports of "muskies" caught in Curtis lake in recent years, but none have ever taken in the nets. Suckers are now present though none were reported in 1939 or 1940.

This project was interrupted by the war, and the immediate effect of the hybrids was never checked. Nothing more was done until 1946, at which time test netting showed that bass were scarce and perch still badly stunted.

In view of these findings, a program of perch removal was started with the object of thinning the perch population to the point where growth could improve.

Removal has been effected by nets set during the spawning season in 1946 and every year thereafter. Total removal to date amounts to 1,370 pounds or 62.3 pounds per acre as follows:

Table II
Perch removal from Curtis Lake

Year	Pounds	Pounds Per Acre	Number of Fish	Number Per Acre	Number Per Pound
1946	389	17.6	12,016	547	30.9
1947	379	17.2	8,268	376	21.8
1948	215	9.8			
1949	387	17.6	4,020	183	10.4
Totals	1,370	62.3			

The most obvious change in conditions in the course of the experiment has been the increase in the average size of perch. This has come about in three ways: by an increase in growth rate as reflected by increase in length of fish of a given age in succeeding years, by a change in size and age distribution, and by an increase in condition of the fish.

In discussing growth rates, it is necessary to use calculated lengths to help fill the gap between 1939 and 1946 when there were no direct observations. These are introduced with the realization that such data are not as accurate as direct measurements and may be subject to error. Average lengths of each age group in each year are presented in Table III and Figure 1. All lengths between 1939 and 1946 are calculated from measurements of scales collected in 1946. Lee's formula was used, the constant being derived from the regression line of fish and scale measurements. These, together with the measurements in 1939, indicate a gradual increase in size of all age classes up to 1945 followed by a sudden drop of most classes in 1945 or 1946 and a recovery in 1948 and 1949.

It is impossible to say whether the introduction of hybrids in 1946 was in any way responsible for the increase in growth rate from 1939 to 1945. The sudden drop coincides with survival of a very large year class spawned in 1944. This situation appears to resemble that reported in guppies by Shoemaker (1947) wherein fish of

Table III

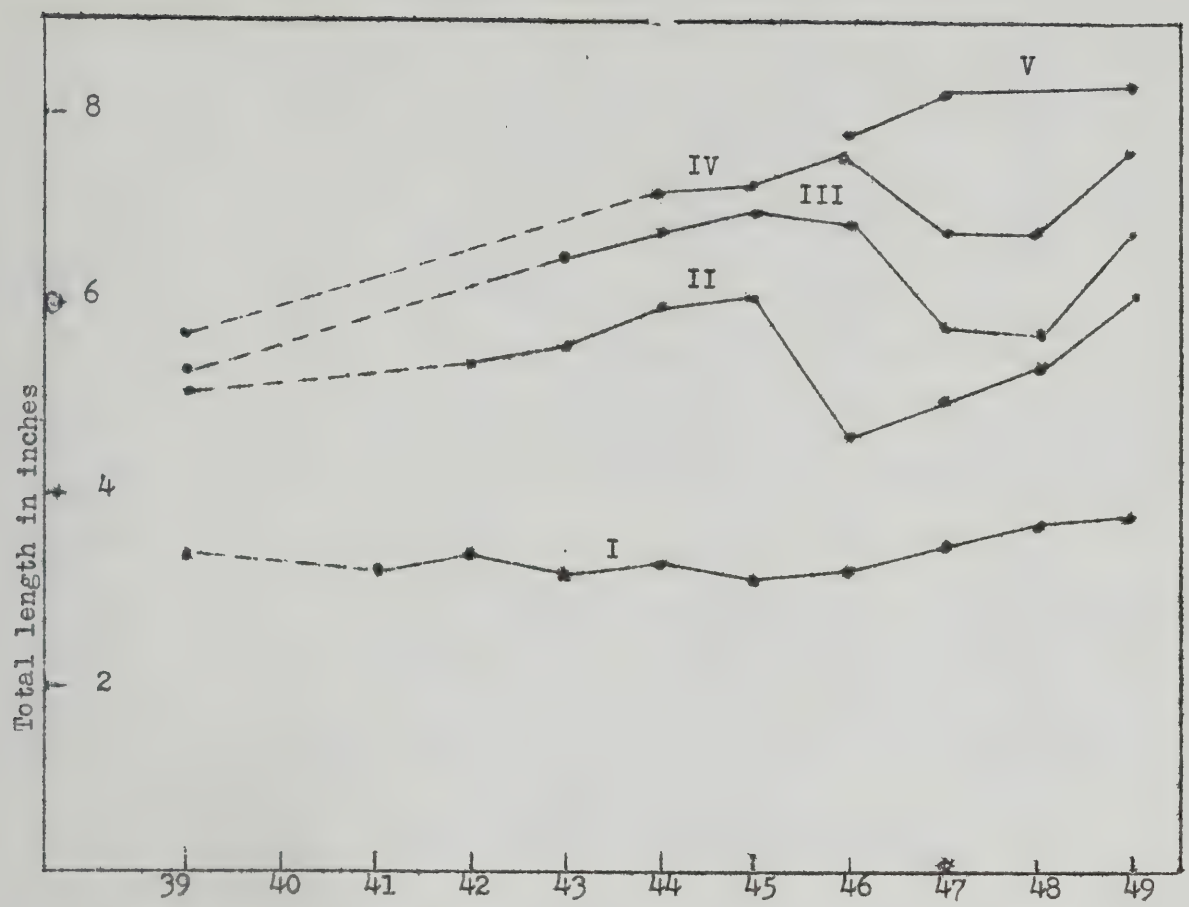
Average total length of perch by age and year of collection

Age	1946 Number	1946 Avg. TL.	1947 Number	1947 Avg. TL.	1948 Number	1948 Avg. TL.	1949 Number	1949 Avg. TL.
I	1	3.2 in.	81	3.5 in.	20	3.7 in.	41	3.8 in.
II	70	4.6	3	5.0	66	5.3	38	6.1
III	31	6.9	295	5.8	2	5.7	45	6.8
IV	44	7.6	19	6.8	53	6.8	4	7.7
V	35	7.8	3	8.3	1	6.6	13	8.3
VI	11	8.0	1	7.7			1	8.9
VII	1	8.4	1	8.2				

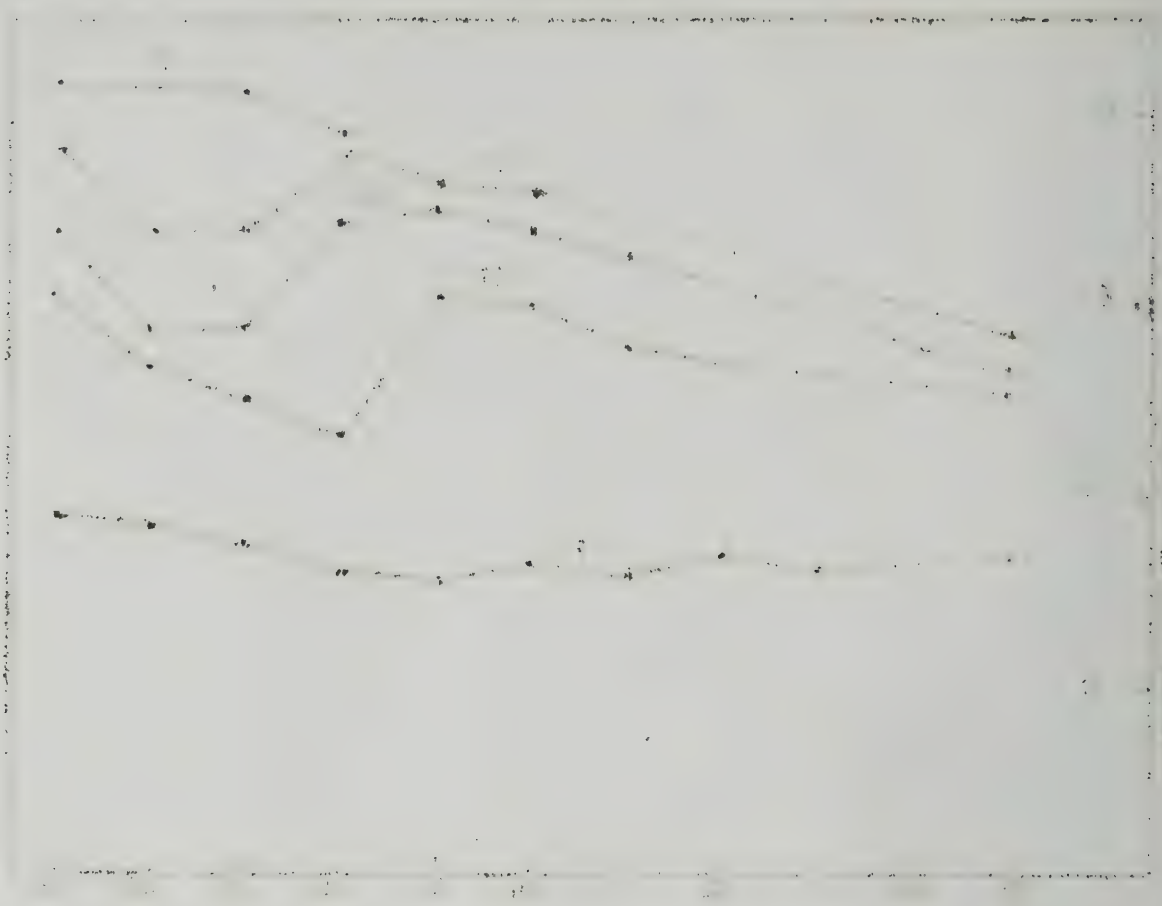
Table III A

	Female			Male		
Age	1947	1948	1949	1947	1948	1949
I	3.4	3.7	3.8	3.5		3.8
II		5.5	6.3	5.0	5.2	6.1
III	6.0		7.0	5.5	5.7	6.5
IV	6.9	7.0	7.7		6.3	
V	8.6		8.3	8.2	6.6	

Figure 1



Average length of different age groups of perch in different years



predator size continued to increase in size and held the younger generation to a minimum through cannibalism until their numbers decreased to a point that allowed more young fish to survive. The increase in growth rate in Curtis lake up to 1945 suggests a decline in numbers, which theory is supported by the small number of larger fish in 1946. The survival of the large 1945 year class resulted in a great increase in numbers and corresponding decrease in growth rate.

It is believed that without intervention in 1946 and later years, recovery of growth rate would have been about as slow as the previous recovery. Removal of perch aided natural mortality in decreasing the number of fish present so that the growth rate increased to about the previous maximum within three years.

It is interesting to note that the present growth rate of perch for the first four years is slightly greater than that reported by Beckman (1949) for Michigan or by Lloyd and Moe (1944) for Minnesota. These figures are compared in Table IV.

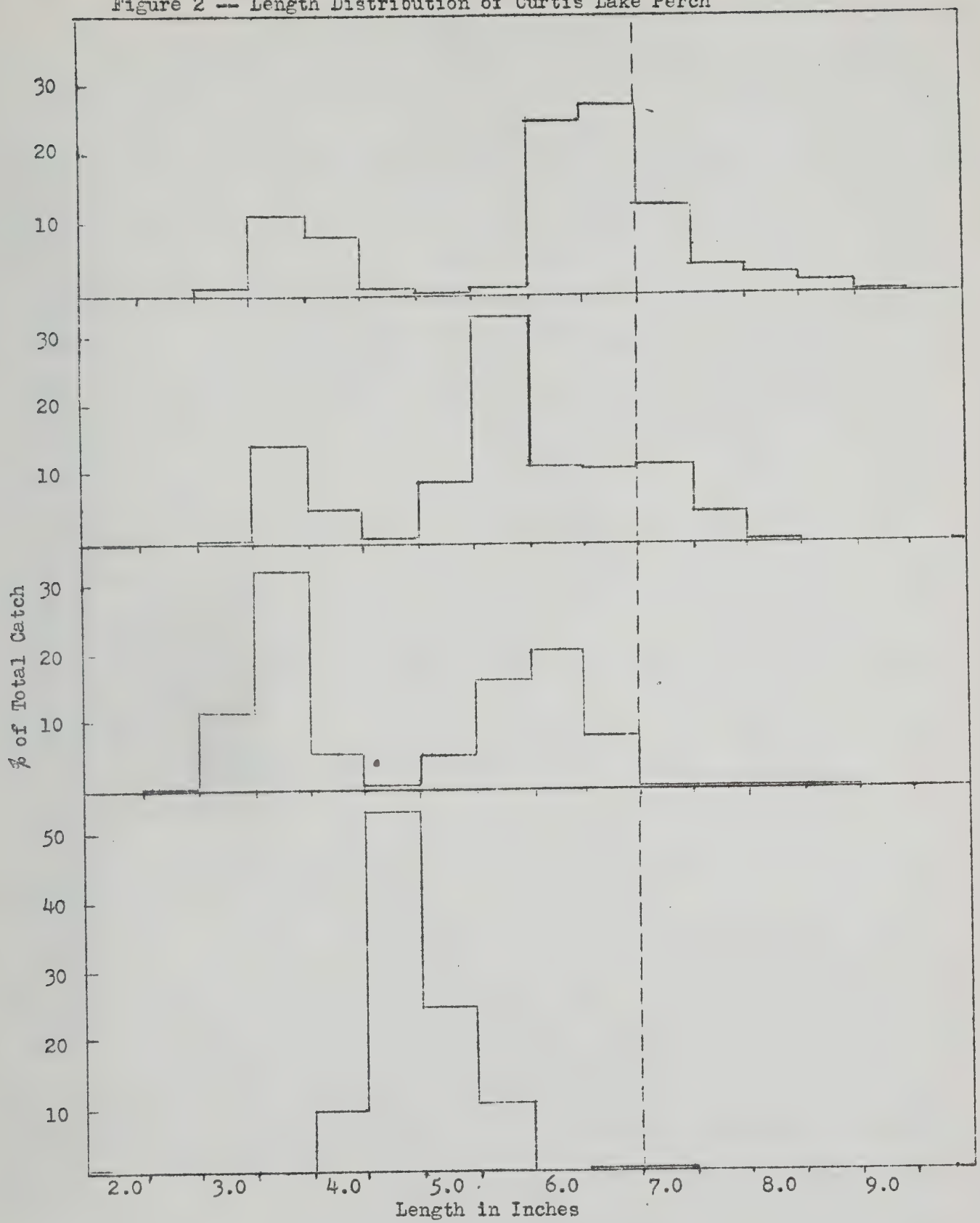
Table IV
Lengths of perch at different ages

	Curtis Lake		Michigan	Minnesota
Age	1946	1949	Beckman	Lloyd & Moe
I	3.2	3.8	4.1	2.4
II	4.6	6.1	5.8	4.5
III	6.9	6.8	6.4	6.3
IV	7.6	7.7	7.5	7.7
V	7.8	8.3	8.5	9.2

The size and age distribution of the fish have changed greatly since 1946 as illustrated in Figure 2. In 1946, about 97 per cent of all perch removed were two year old fish between 3.75 and 5.75 inches in total length and only about 1.5 per cent were seven inches or over. While the actual size range of perch has not increased since 1946, growth and recruitment have resulted in a much broader distribution through that range. In 1948, 16.3 per cent and in 1949, 23.2 per cent of all fish removed were over seven inches in total length.

Removal during the spawning season seems to have little or no direct effect on the hatch. In 1946, when there had been no previous removal, there were practically

Figure 2 -- Length Distribution of Curtis Lake Perch



no yearlings. This year class (1944) has been conspiciously scarce throughout the experiment. After removal in 1946 a crew covered the lake for several days removing all perch spawn they could find. Nevertheless, the yearling class in 1947 was the largest in any of the four years. Removal does, of course, increase survival by decreasing predation.

The third factor in the increase in average size is an increase in condition or fatness of the individuals. The improvement of condition was quite noticeable in 1949. Up to this time, all perch were thin and the larger ones were definitely emaciated. In 1949, however, all fish were in good condition. For the first time since the experiment started, the lake contained fish that should be attractive to the fishermen. Direct data on this is lacking; weights of individual fish were largely ignored during removals because they are subject to great and sudden changes during spawning.

An idea of the changes that occurred can be derived from the following comparison of two collections.

Year	Number	Size Range	Average Total length	Pounds	Average Weight
1946	627	5 - 9	7.1	62	0.099
1949	826	3 - 9	6.0	77	0.093

In other words, fish averaging six inches in 1949 weighed almost as much as fish averaging seven inches in 1946.

Very few bass were taken before 1948, and size and age distribution of these few was too erratic to give any information on growth rate. In 1948, large numbers of two year old bass appeared in the nets, and the same year class was plentiful in 1949, though only three - 2 year olds were taken in this year. This 1946 year class is definitely slow growing, three year old fish averaging 6.9 inches in total length. The improvement of growth rate demonstrated by the perch has not extended to the bass.

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Table V
Ages and Lengths of Largemouth Bass

	1946		1947		1948		1949	
Age	No.	Average T. Len.	No.	Avg. TL.	No.	Avg. TL.	No.	Avg. TL.
I			4	3.2			1	3.5
II	2	5.6			50	5.2	3	5.1
III	2	6.2	3	9.9			51	6.9
IV			1	9.4	7	12.9		
V	2	11.7	1	10.3			2	14.8
VI	1	12.2	1	13.9	3	15.1		
IX							1	16.9

Actual removal operations to date exclusive of the collection of data, have required about 10 man days per year. It could have been done for a total cost of about $300. For the same money the lake could have been poisoned and restocked with bass. If this had been done in 1946, it is safe to assume that the lake would have produced legal (10 inch) bass in 1949, as contrasted to the undersized bass now present. So far as the bass are concerned, this method cannot be considered as effective as poisoning, especially since further removal is planned which will increase the cost. On the other hand there is still a good chance for a satisfactory bass population and meanwhile there is a perch population of average quality, though by no means remarkable.

NATURAL REPRODUCTION IN MINNESOTA GAME FISH LAKES DURING 1949

Raymond E. Johnson

I. INTRODUCTION

Minnesota fisheries managers, including biologists and propagation men, have long been interested in the quality and quantity of naturally produced game fishes in the many lakes of the state. Aside from the purely academic interest in knowing more about natural reproduction, knowledge is desirable (1) to serve as a basis for allotting quotas of artifically produced young so that hatchery fishes might not be wasted but might be used to greater advantage, (2) to give a hint as to the future population of a game fish lake, and, (3) to give clues on the important problem of what is needed in the way of annual recruitment to maintain a sport fishery for desirable game species.

In 1945, efforts were first made to estimate the quantity of naturally reared fingerlings in lakes surveyed by the research unit. This work still continues as part of research surveys. Since 1948, propagation unit crews have been using larger seines to achieve the same estimation. A description of the methods used, together with presentation of the results so far as they can now be interpreted, make up the body of this investigational report.

II. METHODS

Collections of fish for the purpose of determining extent of natural reproduction are simply made. A known area of lake shoreline is seined, the fish are sorted by species and counted or weighed, and the data are converted to number or pounds of fingerlings per shoreline acre seined.

Seining usually is done late in the summer (August) when important game species have had at least 100 days of growth and have survived what must be the most critical period of their lives. Evidence exists that at the end of the 100 day period, the 1 : 5 ratio between predaceous fish young and forage fish young is attained and does not change in Minnesota lakes throughout the remainder of the life span.

Nets used for this purpose range from 25 foot minnow nets up to 600 foot nets 12 feet in depth. Their only uniform characteristic is the one-fourth inch mesh common to all. Nature of the lake, character of the shoreline, and amount of labor available determine the size of net used.

There is considerable amount of inexactness in this work. If in a seine haul covering one-tenth of an acre, a few important walleye fingerlings are overlooked, the error of omission is multiplied by ten when the final calculations are made on the basis of fingerlings per acre. This is nullified in lakes where five or more acres may be seined and where fish not counted or escapes due to faulty handling of the net will be cut by eighty per cent when the final computations are made. It is recognized that size of sample is very small, particularly when the lake being seined is over 100 acres in area, and a wide range of error must be expected. The data warrant no statistical treatment beyond computation of means.

This work is being modified so that nets of the same length and mesh are used over the same lake sites at roughly the same season each year. Errors are then assumed to be relatively constant year after year and fluctuations of catch will more truthfully represent fluctuations in fingerling abundance.

III. PRESENTATION OF DATA

1. Scope of Investigation

During 1949, 203 lakes were examined to determine extent of game fish natural reproduction. Eighty-seven were seined during the course of normal research unit survey work and were handled with seines not exceeding 50 feet in length. Propagation crews examined 116 lakes sometimes with seines up to 600 feet long. These lakes were scattered at random throughout the state's lake regions, and except for the extreme northeastern tip of Minnesota all areas are well represented in the following data. During 1948, 164 lakes were covered in similar fashion but information from only 87 of them is used sparsely in this report for comparative purposes.

2. Numbers of Naturally Produced Young

Gross data showing average numbers of fingerlings captured per acre in the lakes where each species was found are presented in Table I. It may be readily seen that numbers of fish in a shoreline acre sometimes are great.

Lumping of all information into Table I has obscured significant facts apparent in individual lakes or in groups of lakes. It is impossible to present the catch for each of the 203 lakes, but the data are broken down somewhat in succeeding tables. In the following discussion of the reproductive success of each species it has been found possible and necessary to divide the state into several regions based on the similar natural reproductive success found in the many lakes of each region. These regions will be explained more fully in a following section.

a. Northern pike.

Young of this species were found in 35 lakes and averaged 23 per acre for all of those waters. High of 175 per acre was reached in Waukenabo lake, Aitken county and 72 per acre were found in one Crow Wing county lake. On a regional basis, the north central area showed highest production with 61 fingerlings per acre averaged over the seven lakes seined there, south central and eastern regions showed only fair production with 12 to 36 fingerlings per acre in the 11 seined lakes, and all other areas were poorer. In 1948 the north eastern area was good and the north central was excellent again, but no region came up to the exceptional fingerling production noticed in 1947. Unfortunately, no exact data are worked up from 1947 field notes to provide numerical comparison.

b. Walleye.

Natural production of walleye pike was found to average 1,258 fingerling per acre in the 27 lakes where the species was taken. This figure compares well with a mean production from 66 walleye ponds operated in 1942, 1943 and 1944 of 2,111 fingerling per acre at the age of roughly 100 days. A high production of 29,045 fingerlings per acre was obtained in Moose lake, Itasca county, and 3,069 were found in Mille Lacs. Regionally, the north eastern and north central areas showed the best production with an average of more than 2,000 fingerlings per acre in the 16 lakes seined there. The northwest region showed fair production with from 43 to 150 fingerlings per acre being taken from those lakes. All other areas were poor and catches averaged fewer than 50 per acre. In 1948, the northwest and south central regions were tops with an average of 44 fingerlings

per acre, and the north central area was only fair with 22 per acre. There were large local hatches in Ille Lacs, Big Stone lake on the western border, and the upper end of Lake Pepin in the Mississippi river.

c. Largemouth bass.

Young of largemouth bass were taken at an average rate of 432 per acre for all of the 132 lakes where they were found. In contrast, 59 lakes produced only 95 fingerlings per acre during the 1948 season. Whipple lake, Aitken county, yielded 7,588 and Mary lake, Wright county, 6,523 fingerlings per acre. Regions of excellent natural reproduction during 1949 were the eastern, north central, and south central in which 50 lakes produced an average of 750 to 900 fingerlings per acre. The northeast and southwest regions had 45 lakes from which 100 to 244 were taken per acre, and all other lakes yielded slightly less than 100 per acre.

The chief difference between 1948 and 1949 production is not in the lower production of the earlier year but in the fact that the northeast region had almost no natural bass hatch in 1948 because of abnormally high water levels during spawning times.

d. Smallmouth bass.

Smallmouth bass were taken from only seven lakes, but averaged 72 per acre from those bodies of water. All northeastern lakes seemed to produce some smallmouth fingerlings in 1949, and Orange lake, Itasca county, yielded 227 per acre. The Mississippi river and two southern streams (Blue Earth river and Cottonwood river) again produced good natural hatches. On a regional basis, the north eastern area was high while the eastern and north central regions showed good production. In comparison with 1948, the present year seems about the same, but both years were far above the ten year period from 1938 through 1947 when smallmouth bass natural reproduction was almost nonexistent.

e. Silver bass and channel catfish.

These species were found in only eight lakes during the 1949 seining, mainly in the southwest portion of the state, but attained some abundance there. More than 100 young per acre were seined from Okabena lake, Nobles county, Bass lake, Faribault county, and Lake Elysian, Waseca county. Good hatches of catfish were also recorded from the Cottonwood river above New Ulm.

f. Sunfish.

Bluegills, pumpkinseeds, green and orangespot sunfish were seined from 142 lakes in numbers averaging 1,485 per acre. High numbers of 20,000 per acre were taken from Madison lake, Blue Earth county, 16,000 per acre from Big Vermilion lake, Cass county, and 12,000 per acre from Henry lake, Douglas county. The south central region led with an average of 2,800 fingerlings produced per acre averaged over the 29 lakes in that area. Northeast, north central, and southwest regions contained 74 lakes yielding 1,000 to 1,900 fingerlings per acre. All other regions showed production down to 277 per acre, and a lake yielding fewer than that number is a rare exception. In 1948, the eastern region was high followed by the south central region, and all production in general was about 40 per cent as good as in 1949.

g. Perch.

Young of this species averaged 8,425 per acre in the 130 lakes where they were found. This average undoubtedly is influenced by Hunter lake, Cass county which yielded 752,000 per acre and by Red Sand lake, Crow Wing county, which showed 60,000 per acre. Regionally, the north central area was high by far with 40 lakes there averaging 24,168 per acre. Northeastern and northwestern areas were good, and even the other areas which did not produce well averaged 647 perch over the 42 lakes, ranging from 159 up to 1,500 fingerlings per acre. 1948 perch production was not spectacular and averaged only one-sixth of the 1949 yield. Again, the north central region was high with 4,728 fingerlings per acre in 12 lakes and 22,000 per acre produced in one Crow Wing county lake.

h. Crappies.

Young black and white crappies were found in 51 lakes and averaged 321 per acre there. Examination of the yield on a regional basis shows that the north central and south central regions were high with 20 northern lakes averaging 620 fish per acre and five southern lakes averaging 421 per acre. Birch lake, Cass county and Round lake, Ramsey county, yielded 3,087 and 3,180 fingerlings per acre respectively. 1948 production was better with 1,328 being removed from an acre in each of 22 lakes, and with the north central region having nine lakes giving up 2,646 per acre on the average. A high of 20,000 per acre was found in Bass lake, Crow Wing county. There was no crappie production in the northeast region during 1942 and apparently none during 1944.

i. Minnows.

Adult minnows, darters and other small forage fishes were very abundant in all regions; taken from 136 of the 203 seined lakes in numbers averaging 3,844 per acre. Northeast and southeast areas showed highest production, averaging 12,900 per acre in the 18 lakes seined there. Production in individual lakes reached 124,000 per acre in an Itasca county lake, 24,300 in Bavaria lake, Carver county, and 17,600 in Hughey lake, Hennepin county. 1948 production was even better in the northwest and south central regions, but the average take from 43 lakes in 1948 was only 3,004 per acre seined, (Table 3).

j. Bullheads.

Young black, brown and yellow bullheads were taken from 41 of the 203 lakes and averaged 1,238 per acre there. The 1948 hatch, in contrast, amounted to an average of only 281 fingerlings from each acre in the 10 lakes seined. Bullhead young were most abundant in the south central region where 12 lakes contained 3,012 per acre, and in the north central, northwest and southwest regions where the take from 23 lakes averaged 577 per acre. Highest reproduction was found in Eden lake and Brown's lake, Stearns county, with 17,400 and 6,800 fingerlings per acre respectively.

k. Other rough fish.

Carp, sheepshead and buffalo all occurred together in the same general south western Minnesota region. Some buffalo were seined in the northwest, however and carp extended into the south central region in considerable numbers. In the nine lakes where carp fingerlings were found, they averaged 45 per acre with a

high of 170 in Lake Elysian, Waseca county. Sheepshead were taken in five lakes and averaged 135 per acre there, but ranged up to 423 in Lake Elysian. Buffalo were well over 600 per acre in Lake Shetek, Murray county.

1. Rock bass, suckers, tullibee and burbot were also taken but in numbers so few that no comment is made. Figures on their seine catch may be had from Tables 1 and 2.

3. Catch According to Size of Net.

Early in this work it became apparent that larger seines used by propagation unit crews were catching different species of fingerlings more abundantly than were smaller seines operated by research unit crews. The larger deeper nets reaching into deeper waters and covering greater areas took more smallmouth bass, crappies, catfish, sheepshead, silver bass, and carp (Table 2). Seines of smaller size rarely operating in waters more than four feet deep or covering more than a few thousand square feet at a haul were more successful in capturing walleyes, northern pike, and the fish living in weedy areas such as largemouth bass, perch, and bullheads. Both took minnows and sunfish equally well.

It was also found that large seines covering vast areas and many habitats give erroneously low fish counts in terms of acreage seined, for the species in question or sought after might have been present in some concentration within a small area, but the widely encompassing seine's area must be used in all abundance computations.

4. Reproduction in Various Regions of Minnesota.

Critical examination of the seining data revealed that both in 1948 and 1949, reproduction of the species mentioned above occurred according to clearly defined geographical pattern. For example, the northeastern area of Minnesota apparently produced no bass during 1948, but the area retained its unity while producing heavily in 1949. There seem to be 7 such areas, the lakes of which behave as units in their reproductive processes year after year. Climatic conditions varying over the state each spring and summer undoubtedly foster this reproductive pattern. Lake characteristics and ecological traits also help to set reproductive patterns within the seven areas. Species distribution aided in the delimitation of a concise south-western group of lakes where rough species are more prevalent.

IV. CONCLUSIONS

General indications are that natural reproduction of desirable fish species is tremendous at times, almost lacking at others, and therefore is variable from year to year in any one location. It is clear that certain areas of Minnesota's lake region behave as concise units in the reproductive behavior of their fishes.

Production of fingerlings in artificial ponds must be used in considerable volume if it is to equal production of fingerlings in natural lakes during favorable years, or must be used in areas of poor natural reproduction as a supplement. Even today's artificial pond production of fingerlings may fall short of natural lake production under favorable climatic conditions. Without doubt, the replenishment of angling stocks is dependent on a variable and potentially tremendous production of young fish.

Attach 5
mjt
1/17/50

Table 1

Shoreline Seining Data from 203 Minnesota Lakes during 1949

Species	Number of Lakes Where Taken	Average Number of Fingerlings Found per Acre Seined
Gamefishes*		
Northern pike	35	23
Walleye	27	1258
Largemouth bass	132	432
Smallmouth bass	7	72
Silver bass	6	80
Channel catfish	2	109
Panfishes*		
Sunfish (four species)	142	1435
Crappies (two species)	51	321
Rock bass	25	57
Forage fishes*		
Minnows (adults and young)	136	3844
Rough fishes*		
Carp	9	43
Suckers	31	116
Buffalo	3	147
Bullheads (three species)	41	1238
Perch	130	8425
Sheepshead	5	135
Burbot	2	20
Tullibee	4	4

*Grouped according to Minnesota laws and public attitude.

Table 2

Comparison of Fingerling Numbers Captured by Large and Small Seines on Contiguous but not Identical Lakes

Species	Seines 15' x 5' x ¼" to 50' x 5' x ¼" Used in 87 Lakes		Seines 75' x 6' x ¼" to 600' x 12' x ¼" Used in 116 Lakes	
	Lakes Where Taken	Fingerlings Per Acre	Lakes Where Taken	Fingerlings Per Acre
Gamefishes				
Northern pike	18	39	17	7
Walleye	9	3390	18	192
Largemouth bass	58	616	74	128
Smallmouth bass	1	12	6	82
Silver bass	-	-	6	80
Channel catfish	-	-	2	109
Panfishes				
Sunfish (four species)	69	1245	73	1709
Crappies (two species)	20	89	31	470
Rock bass	10	73	15	47
Forage fishes				
Minnows (adults and young)	82	3489	54	4421
Rough fishes				
Carp	2	17	7	50
Suckers	18	150	13	68
Buffalo	1	3	2	438
Bullheads (three species)	28	1673	13	302
Perch	69	14367	61	1703
Sheepshead	-	-	5	135
Burbot	2	20	-	-
Tullibee	-	-	4	4

Table 3

Shoreline Seining Data from 87 Minnesota Lakes During 1948, Obtained from Seines 75' x 6' x ¼" to 400' x 12' x ¼" only

Species	Number of Lakes Where Taken	Average Number of Fingerlings Found Per Acre Seined
Gamefishes		
Northern pike	16	18
Walleye	11	27
Largemouth bass	59	95
Smallmouth bass	8	19
Panfishes		
Sunfish (four species)	54	612
Crappies (two species)	22	1328
Rock bass	4	12
Forage fishes		
Minnows (Adults and young)	43	3004
Rough fishes		
Carp	1	27
Suckers	12	51
Bullheads (three species)	10	231
Perch	55	1415

Table 4

Regions of Similar Natural Reproduction as Revealed by Shoreline Seinings of Fingerlings During 1949 *

Region Number, Location, and Number of Lakes Seined	Counties Within Region	
1. North eastern (27 lakes)	Cook	
	Lake	
	St. Louis	
2. Eastern (13 lakes)	Itasca	Carleton
	Koochiching	Pine
		Kanabec
		Isanti
3. North central (50 lakes)	Cass	
	Crow Wing	
	Aitken	
4. South eastern (10 lakes	Mille Lacs	Chisago
		Washington
		Ramsey
5. South western (44 lakes)	Le Sueur	Dakota
	Rice	Scott
	Waseca	Carver
	Blue Earth	Hennepin
	Faribault	
	Watonwan	
	Martin	
6. North western (22 lakes)	Jackson	Mahnomen
	Nobles	Clearwater
	Murray	Becker
	Lincoln	Ottertail
	Lyon	Hubbard
	Freeborn	Wadena
		Beltrami
7. South central (33 lakes)	Douglas	
	Grant	
	Pope	
	Kandiyohi	
	Stearns	
	Morrison	
	Sherburne	
	Wright	
	Todd	

* Only 199 lakes are included. Of the 203 mentioned in Table 1, 4 have been omitted here because of their isolated geographic position which made their being included in any of the seven areas a bit dubious.

Table 5

Numbers of Fingerlings Captured per Acre of Shoreline Seined in Each of the Seven Regions of Similar Natural Reproduction

	1		2		3		4		5		6		7	
	Lakes where found	Number per acre	Lakes where found	Number per acre	Lakes where found	Number per acre	Lakes where found	Number per acre	Lakes where found	Number per acre	Lakes where found	Number per acre	Lakes where found	Number per acre
Per [illegible] - 1948														
Lakes seined	6		3		12		1		0		38		26	
N. Pike	1	26	2	15	5	32	1	2	-	-	2	15	5	9
Walleye	1	1	-	-	2	29	1	18	-	-	3	44	4	22
L.M. Bass	5	22	3	152	11	217	1	6	-	-	19	47	20	88
S.M. Bass	1	14	-	-	-	-	-	-	-	-	6	22	1	9
Sunfish	3	206	3	1267	12	398	1	450	-	-	12	446	23	784
Perch	5	1012	3	459	10	4748	-	-	-	-	22	675	15	603
Crappies	2	1557	2	72	9	2646	1	1500	-	-	2	160	6	54
Bullheads	-	-	-	-	2	215	-	-	-	-	5	35	3	735
Suckers	2	52	1	2	-	-	-	-	-	-	4	64	5	49
Minnows	4	390	-	-	2	420	1	500	-	-	31	3892	5	1125
Large Seines - 1949														
Lakes seined	15		0		26		6		44		13		10	
N. Pike	3	5	-	-	6	11	1	10	2	5	2	2	3	5
Walleye	3	37	-	-	8	394	1	11	-	-	4	43	2	5
L.M. Bass	9	162	-	-	19	76	6	244	21	156	11	72	8	98
S.M. Bass	1	327	-	-	1	75	1	53	-	-	2	2	1	33
Sunfish	3	966	-	-	17	1918	6	745	27	1506	10	277	10	4136
Perch	13	1136	-	-	20	6470	1	159	14	1535	8	1745	5	680
Crappies	4	189	-	-	12	620	1	3180	5	201	4	22	5	421
Bullheads	-	-	-	-	2	401	-	-	6	365	3	214	2	144
Suckers	1	16	-	-	3	91	1	110	-	-	5	95	3	4
Minnows	2	62720	-	-	-	-	2	4575	42	2195	7	1670	1	240
Small Seines - 1949														
Lakes seined	12		13		24		4		0		9		23	
N. Pike	-	-	4	12	7	61	-	-	-	-	1	14	6	36
Walleye	4	7559	1	44	1	33	-	-	-	-	2	23	1	150
L.M. Bass	6	216	11	888	14	775	3	101	-	-	7	98	17	754
S.M. Bass	-	-	1	12	-	-	-	-	-	-	-	-	-	-
Sunfish	6	1207	12	334	21	1351	3	1020	-	-	8	431	19	2097
Perch	7	5142	12	5273	20	41902	2	262	-	-	8	4761	20	759
Crappies	-	-	5	30	6	109	1	14	-	-	1	163	7	114
Bullheads	1	43	3	342	7	870	-	-	-	-	5	710	12	3012
Suckers	-	-	6	133	1	429	-	-	-	-	4	296	7	42
Minnows	10	5416	13	395	24	1944	4	11058	-	-	9	3067	22	4628

SPORT FISHING IN FERTILIZED AND UNFERTILIZED PONDS

Donald F. Hansen and George W. Bennett
Illinois Natural History Survey, Urbana

The value of fertilization as a technique for the improvement of hook and line fishing in small ponds has been under investigation in Southern Illinois during the past three years (1947-49 inclusive). Six ponds ranging from 0.9 to 1.2 acres each are used in the study. The ponds are located at the University of Illinois, Dixon Springs Experiment Station, in Pope County. After first clearing out old fish populations with rotonone, the ponds were stocked with largemouth bass and bluegills in the fall of 1946. Three of the ponds were fertilized, each at the same rate, during the next three summers; no fertilizer has been used in the other three control ponds. All six ponds were fished during the summers of 1947, '48, and '49 and complete records were kept of hours of angling, number of fish harvested and weight of fish harvested.

In stocking and fertilizing the ponds, we have followed, (with some major modifications), procedures worked out, and described by Swingle and Smith (1942). The three ponds selected for fertilizer treatment were accordingly stocked with 100 bass and 1,500 bluegills per acre -- the other three ponds with 30 bass and 400 bluegills per acre. Swingle and Smith have urged the heavier stocking in the fertilized ponds as a means of making better use of the larger supply of fish food organisms which they believe are produced in fertilized ponds. At the time of stocking the bass measured 6.0 to 10.0 inches and the bluegills about 1 inch. Harvesting of bass started in all ponds in June 1947 and of bluegills in June 1948.

A "complete" inorganic fertilizer containing nitrogen phosphorus and potassium in the ratio 8 - 12 - 2 1/2 was used in ponds A, B, and C in 1947, '48, and '49, at the rate of 420 pounds per acre annually. Pulverized limstone was also applied at the rate of 60 pounds per acre annually. (Swingle and Smith recommended approximately 800 - 1400 pounds per acre annually of a similar fertilizer.) These materials were introduced in 4 equal treatments a year between early May and early September. They were broadcast into the shallow water along the sides of the ponds and into the deep water along the dams. Dense beds of chara died in the fertilized ponds during the first summer of treatment and have not reappeared since, while chara has flourished in the unfertilized ponds.

Natural History Survey biologists fished each of the six ponds 2 to 4 hours a week for 12 to 14 weeks during each of the three summers. They made it a standard practice to keep all bluegills measuring 6 inches or longer and bass measuring 10 inches or longer. Fish below those sizes were measured and returned to the ponds.

Fishing by the general public was allowed under a permit system which involved compulsory reporting at the end of each trip. The public concentrated most of their efforts on fertilized pond B. and unfertilized pond E. Fishermen could keep bluegills of any size, but were required to obey the 10 inch bass law.

Results. -- On the evidence obtained from the few ponds used, the benefits derived from fertilization show mainly in bluegill fishing, ie. the larger average size of bluegills and in the slightly higher rates of capture, in numbers and pounds per hour (Table 1). Bass fishing was little or no better in the fertilized ponds than in the controls. The ratio of pounds of bass kept to pounds of bluegills kept was highest in the controls.

The larger average weight of the bluegills in the fertilized ponds (Table 1), and the greater abundance of 7 1/2 inch and 8 inch bluegills (Table 2) might make a favorable impression on fishermen. And some pond owners might be interested in fertilizing their ponds in order to have such fish.

It is doubtful if the fishermen could have been aware of the slightly higher rates of capture of bluegills in the fertilized ponds. The difference in rates amounted to only 0.34 fish per hour, and 0.11 pound per hour.

Based on the creel from three years of angling this program of fertilization combined with a hook and line harvest of fish cannot be justified as a paying farming operation. In other words the annual cash value of the increased catch attributable to fertilization would seldom equal the $9.70 per acre spent annually on fertilizer. To illustrate from our results, the one acre fertilized ponds yielded, in bass and bluegills combined, only 0.10 pound of fish per hour more than the unfertilized ponds, or only 10 pounds more of fish in 100 hours of fishing. This premium catch of 10 pounds in 100 hours can be considered worth about $3.00 as dressed fish at current retail prices. At this rate 325 hours of fishing would be necessary before the value of the increased catch equalled the annual cost of fertilizer.

On the basis of our own observations, it is unusual for a pond owner and his family to fish his pond more than 50 man-hours per year. Certainly it would be an exceptional farm family that could find time for 325 hours of fishing a year.

Swingle (1947) shows that ponds in Alabama receiving 1,400 pounds 6.6 - 8 - 2 fertilizer per acre, and drained after one growing season, contained abourt 3 times the weight of fish of untreated ponds. Some expansion of the fish populations of the fertilized ponds in our experiment is assumed, but this population expansion resulted in a rate of catch in pounds per hour of only 1.35 times that of unfertilized ponds. It remains to be seen what yearly rates of treatment greater than 420 pounds per acre might do for fishing.

Literature cited

Swingle, H. S.
1947. Alabama Agricultural Experiment Station Bulletin No. 264 34 pp.

Swingle, H. S. and E. V. Smith
1942. Alabama Agricultural Experiment Station Bulletin No. 254 23 pp.

Table 1.-- Catch data on bass fishing in 1947, 1948 and 1949, and bluegill fishing in 1948 and 1949, in 3 fertilized and 3 unfertilized ponds, based on fish kept. Fishermen observed a 10-inch length limit on bass.

	Fertilized Ponds				Unfertilized Ponds (Controls)			
	Pond A	Pond B	Pond C	Summary	Pond D	Pond E	Pond F	Summary
Largemouth Bass								
Number of hours	175	584	182	941	173	312	149	634
Number of fish	84	73	24	181	47	35	30	112
Pounds of fish	51	48	11	110	35	29	22	86
Av. weight per fish	0.61	0.66	0.46	0.58	0.74	0.83	0.73	0.77
Number per man-hour	0.48	0.13	0.13	0.25	0.27	0.11	0.20	0.19
Pounds per man-hour	0.29	0.08	0.06	0.14	0.20	0.09	0.15	0.15
Bluegill								
Number of hours	136	489	149	774	146	288	124	558
Number of fish	212	344	105	661	73	183	103	359
Pounds of fish	48	90	28	166	16	38	19	73
Av. weight per fish	0.23	0.26	0.27	0.25	0.22	0.21	0.18	0.20
Number per man-hour	1.56	0.70	0.70	0.99	0.50	0.64	0.83	0.65
Pounds per man-hour	0.35	0.18	0.19	0.24	0.11	0.13	0.15	0.13

Table 2.-- Lengths of all fish taken on hooks by Natural History Survey personnel in 3 fertilized and 3 unfertilized ponds. The bass were caught in 1947, 1948 and 1949, the bluegills in 1948 and 1949.

Total Lengths (Inches)	Largemouth Bass		Bluegill	
	Fertilized Ponds	Unfertilized Ponds	Fertilized Ponds	Unfertilized Ponds
1/				
3				1
½			2	10
4			8	43
½	1		10	84
5	2	5	14	80
½	6	8	19	60
6	5	13	45	55
½	6	21	128	71
7	15	23	134	67
½	25	31	63	19
8	26	35	13	1
½	40	30		
9	50	27		
½	37	31		
10	45	17		
½	17	17		
11	34	18		
½	18	7		
12	8	11		
½	3	4		
13	2	4		
½		5		
14	1	3		
½		1		
15		4		
½		1		
16				
½	1	1		
Totals	342	317	436	491

1/ Class limits 2.8 - 3.2

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Based on the creel from three years of angling this program of fertilization combined with a hook and line harvest of fish cannot be justified as a paying farming operation. In other words the annual cash value of the increased catch attributable to fertilization would seldom equal the $9.70 per acre spent annually on fertilizer. To illustrate from our results, the one acre fertilized ponds yielded, in bass and bluegills combined, only 0.10 pound of fish per hour more than the unfertilized ponds, or only 10 pounds more of fish in 100 hours of fishing. This premium catch of 10 pounds in 100 hours can be considered worth about $3.00 as dressed fish at current retail prices. At this rate 325 hours of fishing would be necessary before the value of the increased catch equalled the annual cost of fertilizer.

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	Fertilized Ponds				Unfertilized Ponds (Controls)			
	Pond A	Pond B	Pond C	Summary	Pond D	Pond E	Pond F	Summary
Largemouth Bass								
Number of hours	175	584	182	941	173	312	149	634
Number of fish	84	73	24	181	47	35	30	112
Pounds of fish	51	48	11	110	35	29	22	86
Av. weight per fish	0.61	0.66	0.46	0.58	0.74	0.83	0.73	0.77
Number per man-hour	0.48	0.13	0.13	0.25	0.27	0.11	0.20	0.19
Pounds per man-hour	0.29	0.08	0.06	0.14	0.20	0.09	0.15	0.15
Bluegill								
Number of hours	136	489	149	774	146	288	124	558
Number of fish	212	344	105	661	73	183	103	359
Pounds of fish	48	90	28	166	16	38	19	73
Av. weight per fish	0.23	0.26	0.27	0.25	0.22	0.21	0.18	0.20
Number per man-hour	1.56	0.70	0.70	0.99	0.50	0.64	0.83	0.65
Pounds per man-hour	0.35	0.18	0.19	0.24	0.11	0.13	0.15	0.13

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Total Lengths (Inches)	Largemouth Bass		Bluegill	
	Fertilized Ponds	Unfertilized Ponds	Fertilized Ponds	Unfertilized Ponds
3 1/				1
½			2	10
4			8	43
½	1		10	84
5	2	5	14	80
½	6	8	19	60
6	5	13	45	55
½	6	21	128	71
7	15	23	134	67
½	25	31	63	19
8	26	35	13	1
½	40	30		
9	50	27		
½	37	31		
10	45	17		
½	17	17		
11	34	18		
½	18	7		
12	8	11		
½	3	4		
13	2	4		
½		5		
14	1	3		
½		1		
15		4		
½		1		
16				
½	1	1		
Totals	342	317	436	491

1/ Class limits 2.8 - 3.2

SPORT FISHING IN FERTILIZED AND UNFERTILIZED PONDS

Donald F. Hansen and George W. Bennett
Illinois Natural History Survey, Urbana

The value of fertilization as a technique for the improvement of hook and line fishing in small ponds has been under investigation in Southern Illinois during the past three years (1947-49 inclusive). Six ponds ranging from 0.9 to 1.2 acres each are used in the study. The ponds are located at the University of Illinois, Dixon Springs Experiment Station, in Pope County. After first clearing out old fish populations with rotonone, the ponds were stocked with largemouth bass and bluegills in the fall of 1946. Three of the ponds were fertilized, each at the same rate, during the next three summers; no fertilizer has been used in the other three control ponds. All six ponds were fished during the summers of 1947, '48, and '49 and complete records were kept of hours of angling, number of fish harvested and weight of fish harvested.

In stocking and fertilizing the ponds, we have followed, (with some major modifications), procedures worked out, and described by Swingle and Smith (1942). The three ponds selected for fertilizer treatment were accordingly stocked with 100 bass and 1,500 bluegills per acre -- the other three ponds with 30 bass and 400 bluegills per acre. Swingle and Smith have urged the heavier stocking in the fertilized ponds as a means of making better use of the larger supply of fish food organisms which they believe are produced in fertilized ponds. At the time of stocking the bass measured 6.0 to 10.0 inches and the bluegills about 1 inch. Harvesting of bass started in all ponds in June 1947 and of bluegills in June 1948.

A "complete" inorganic fertilizer containing nitrogen phosphorus and potassium in the ratio 8 - 12 - 2 1/2 was used in ponds A, B, and C in 1947, '48, and '49, at the rate of 420 pounds per acre annually. Pulverized limstone was also applied at the rate of 60 pounds per acre annually. (Swingle and Smith recommended approximately 800 - 1400 pounds per acre annually of a similar fertilizer.) These materials were introduced in 4 equal treatments a year between early May and early September. They were broadcast into the shallow water along the sides of the ponds and into the deep water along the dams. Dense beds of chara died in the fertilized ponds during the first summer of treatment and have not reappeared since, while chara has flourished in the unfertilized ponds.

Natural History Survey biologists fished each of the six ponds 2 to 4 hours a week for 12 to 14 weeks during each of the three summers. They made it a standard practice to keep all bluegills measuring 6 inches or longer and bass measuring 10 inches or longer. Fish below those sizes were measured and returned to the ponds.

Fishing by the general public was allowed under a permit system which involved compulsory reporting at the end of each trip. The public concentrated most of their efforts on fertilized pond B. and unfertilized pond E. Fishermen could keep bluegills of any size, but were required to obey the 10 inch bass law.

Results. -- On the evidence obtained from the few ponds used, the benefits derived from fertilization show mainly in bluegill fishing, ie. the larger average size of bluegills and in the slightly higher rates of capture, in numbers and pounds per hour (Table 1). Bass fishing was little or no better in the fertilized ponds than in the controls. The ratio of pounds of bass kept to pounds of bluegills kept was highest in the controls.

The larger average weight of the bluegills in the fertilized ponds (Table 1), and the greater abundance of 7 1/2 inch and 8 inch bluegills (Table 2) might make a favorable impression on fishermen. And some pond owners might be interested in fertilizing their ponds in order to have such fish.

It is doubtful if the fishermen could have been aware of the slightly higher rates of capture of bluegills in the fertilized ponds. The difference in rates amounted to only 0.34 fish per hour, and 0.11 pound per hour.

Based on the creel from three years of angling this program of fertilization combined with a hook and line harvest of fish cannot be justified as a paying farming operation. In other words the annual cash value of the increased catch attributable to fertilization would seldom equal the $9.70 per acre spent annually on fertilizer. To illustrate from our results, the one acre fertilized ponds yielded, in bass and bluegills combined, only 0.10 pound of fish per hour more than the unfertilized ponds, or only 10 pounds more of fish in 100 hours of fishing. This premium catch of 10 pounds in 100 hours can be considered worth about $3.00 as dressed fish at current retail prices. At this rate 325 hours of fishing would be necessary before the value of the increased catch equalled the annual cost of fertilizer.

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7	15	23	134	67
½	25	31	63	19
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½	40	30		
9	50	27		
½	37	31		
10	45	17		
½	17	17		
11	34	18		
½	18	7		
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PANFISH TO RAINBOWS

Leon D. Johnson

The management of small northern lakes containing populations of stunted panfish has long been a problem in Wisconsin. Various methods of management are being tested and the paper about to be presented deals with a method of solving the problem, in a lake with special qualifications, by completely removing the warm water fish population and replacing it with a trout population.

Little Granite lake is a small dystrophic lake lying in the northwestern part of Wisconsin. The general characteristics of this section of the state include glaciated brownish-gray loams and sand soils in the uplands and muck and peat in the lowlands. The general terrestrial cover over most of the area is forest, dominated by the aspens, oak and jack pine in the highlands and tamarack, balsam, spruce and cedar in the lowlands. The topography is generally hilly or gently rolling and the land is dotted with numerous lakes and ponds.

Little Granite lake is approximately 23 acres in surface area, is landlocked, deep and cold and at one time had dissolved oxygen extending almost all of the way to its 56 foot maximum depth (Table 1). A methyl orange alkalinity test for calcium carbonate indicated that the water is soft (5 p.p.m.). The bottom of the lake is muck. The shoal area is a relatively narrow zone and the bottom drops off sharply a short distance from shore. Aquatic vegetation consists of moderately abundant Chatalia odorata, Brasenia schreberi, Pontederia sp., Sagittaria sp. and Utricularia sp. in a complete fringe around the margin of the lake. Lake bottom samples produced a few snails, while plankton analysis included Daphnia, Bosmina, Holopedium, Ostrocoda, Copedoda, Pandorina, Corethra larva, Diptera larva, Volvox, Spirogyra and Diatoms.

A survey in 1946, indicated that the lake contained a dense population of stunted bluegill (Lepomis m. macrochirus), black crappie (Pomoxis nigromaculatus) and yellow perch (Perca flavescens), in addition to large numbers of yellow and black bullheads (Ameiurus sp.) and a few largemouth black bass (Micropterus salmoides). Fishing success was poor and the lake apparently contained a few fish of a size satisfactory to anglers. From the sport fishery standpoint, it was desirable to have trout in the lake but would the two fish populations get along? It was believed they might since the panfish, bullheads and bass confined themselves more or less to the warmer shoal areas where food and weed protection were abundant, while the trout would probably prefer the deep cold water of the central portions with its food supply of microscopic and larger animals.

Three thousand brook trout (Salvelinus f. fontinalis) fingerlings (four to five inches in length) were planted in the lake in September, 1946. A survey in 1947, plus individual angling efforts, indicated no trout present. Evidently they had not survived the competition of the panfish or other unknown factors had entered the problem. One solution to the problem was thought to be the elimination of the existing population and subsequently an introduction of the more desirable trout population.

With the approval of the property owners and the conservation commission, it was decided to poison the lake. This would enable us to determine whether or not brook trout were still present, as well as enable us to try estimating

Table I

Temperature and Chemistry

Temperature (°F.)

Depth (ft.)	8/5 1939	7/22 1946	8/19 1947	8/30 1947	9/12 1947	9/18 1947	10/3 1947	7/9 1948
0	83	82	80	72	72	-	56	83
5	76	74	79	72	72	-	56	83
10	-	72	79	72	72	-	56	81
15	-	62	70	70	71	-	56	73
20	-	59	60	58	61	-	55	60
25	-	53	53	57	53	-	43	56
30	50	54	50	56	50	-	46	53
35	42	52	50	52	49	-	46	52
40	42	50	50	50	48	-	45	51
45	-	49	50	50	48	-	45	51
50	-	49	50	50	48	-	45	50
55	-	-	-	-	47	-	-	50

Dissolved Oxygen (p.p.m.)

Depth (ft.)	8/5 1939	7/22 1946	8/19 1947	8/30 1947	9/12 1947	9/13 1947	10/3 1947	7/9 1948
0	-	6.6	6.4	7.1	6.9	6.2	7.3	8.0
5	-	6.2	6.6	7.1	6.8	6.6	7.4	8.0
10	-	3.7	6.8	6.9	6.9	6.6	7.3	8.4
15	7.5	3.4	3.9	6.3	4.1	5.7	7.0	8.0
20	7.6	3.2	3.3	1.9	1.3	0.0	7.2	4.7
25	7.7	4.7	2.7	1.5	1.1	0.1	0.0	4.2
30	6.0	3.3	1.7	1.5	0.7	0.0	0.0	4.3
35	4.6	2.5	0.7	0.0	0.3	0.0	0.0	2.4
40	5.3	1.5	0.7	0.0	0.1	0.0	0.0	1.7
45	6.3	0.4	0.7	0.0	0.0	0.0	0.0	0.3
50	6.2	0.2	0.1	0.0	0.0	0.0	0.0	0.3
55				0.0	0.0			0.0

the fish population by the fin clip method, using the formula $P = \frac{AB}{C}$ modified from Schnabel (1938), where P = population, A = number of fish examined in one day, B = number of marked fish in the lake and C = number of returns. Estimates of the fish population could then be compared to an actual count following rotenone poisoning.

With preliminary work completed, the poisoning was accomplished on August 20, 1947. Thirteen biology personnel, six boats and outboard motors assured the even distribution of the 1,500 pounds of powdered derris root, containing 4% rotenone, which produced a 0.5 p.p.m. average concentration of rotenone, as computed from a formula modified from Ziegler and Pillsbury (1946) where: Pounds needed = total acres X average depth X 43,560 X 62.5 X p.p.m. rotenone required.

Estimates of the population by individual species and the numbers of each taken following poisoning are given in Table II. Numbers recovered did not agree closely with the individual estimate for any one species. The total population, as estimated from netting operations, was 15, 597 fish as compared with 15,076 recovered after the poisoning. In this study, however, only 29.2 per cent (1,846) of all marked fish (5,083) were recovered. The indications, therefore, are that 70.8 per cent of the total population was not recovered and that the fin clipping method for estimating fish populations was unsatisfactory. Incidentally, all of the fish collected following the poisoning included only one brook trout.

The carrying capacity of Little Granite lake was calculated by combining the total poundage of fish recovered following the poisoning (Table II) and the percentages just mentioned. If it is considered that recovery of all fish was complete, then the lake had a carrying capacity of 1,434 pounds or approximately 51 pounds per acre. Presuming indications that we were unable to recover 70.8 per cent are correct, the carrying capacity was 4,911 pounds or around 175 pounds per acre. The latter figure, probably more nearly correct, is based on the assumption that the entire lake was productive, which is not necessarily true since the warm water species predominated in the warm shoal areas and the poundage per acre here was probably greater.

In March, 1948, 4,000 sublegal-sized (under seven inches) yearling rainbow trout (Salmo gardnerii irideus) were planted in the lake. Totaling 308 pounds, the plant was well under any calculated carrying capacity. Rainbow trout were used this time primarily because the chemical nature of the lake had changed. Vertical temperature and dissolved oxygen analyses (Table I) made in August 1939 and July 1946 showed Little Granite lake to be suitable for brook trout. Dissolved oxygen analyses taken on August 19, 1947, the day before poisoning, and subsequently, showed an increasing oxygenless hypolimnion, making the lake unsuitable for brook trout. It is believed that the extremely dry summer of 1947 had resulted in a lowering of the water table so that oxygenated water no longer seeped into the lake at the lowermost levels. Also, rainbow trout, with no competition from warm water species, could adapt themselves from cold to warm water areas more easily and thereby have access to the greater food supplies included in the vegetal areas along the shores.

Our records indicate that angling and test netting in 1948 captured rainbow trout ranging from 7.4 to 9.6 inches in length (Table III), an increase of two to three inches over the five month period. Furthermore, the total weight had

Table II

Estimates of Populations by Species and Recovery Following Poisoning

Species	Estimated Population	Fish Recovered following poisoning Number	Pounds
Bluegill	15,112	13,280	1,094.0
Black Crappie	430	242	74.4
Bullhead	332	418	66.5
Perch	199	728	66.3
Pumpkinseed	3	1	-
Largemouth bass	4	403	123.5
Northern pike	1	2	-
Brook trout	0	1	-
Common sucker	0	1	2.3
Totals	16,081 *	15,076	1,434.0

* The estimate of total population without a species breakdown is 15,597 fish.

Table III

Data on Rainbow Trout Captured
and Studied in 1948

	Gill net 7/10/43	Angling Summer 1948	Gill net 12/14/48
No. of fish	14	34	2
Annuli	1	1	1
Length in inches			
Minimum	7.4	7.5	9.4
Maximum	9.5	9.6	9.8
Average	8.4	8.8	9.6
Weight in pounds			
Minimum	.16	.14	.25
Maximum	.35	.30	.31
Average	.22	.22	.28

increased from the 358 pounds planted to 886 pounds, calculated weight, still safely within the carrying capacity. The rapid growth in such a short time supported the original contention that Little Granite could be developed into a trout lake.

In late April, 1949, 2,800 legal-sized rainbow trout totaling 388 pounds were planted, all marked by removal of the left pelvic fin so that further differentiation might be made between the two age groups in the lake and also to gain increased knowledge on growth rates. Seventeen of this group were autopsied and comparisons were made three months later with trout that had adapted themselves to the lake. Of obvious note was the change from the pale white flesh of the hatchery trout to the firm pink flesh attained in the lake habitat. Three months or a year appeared to make little difference in reverting the hatchery fish to wild trout anatomical characteristics.

A voluntary creel census conducted by the biology section gives some idea of fishing on Little Granite lake from the May 14, 1949 opening to the September 7 closing date. Recorded were a total of 346 men who angled 1,025 hours to catch 987 fish. Each fisherman averaged 2.9 hours at the sport and creeled approximately one rainbow trout per hour.

The creel census also brings to light some interesting figures showing that the fish from the two age groups were caught in proportion to the availability. With a total of 6,800 rainbow trout planted, composed of 4,000 of the 1948 plant and 2,800 of the 1949 fin clipped plant, the respective age group composition was 58.8 per cent and 41.2 per cent. The sport catch contained almost identical percentages, with 53.2 per cent last year's trout and 35.2 per cent this year's fin clipped trout. This close correlation is an indication that no major mortality has been suffered by either of the trout plantings. Percentages might have been even closer had we been able to correctly evaluate the 11.6 per cent creeled trout of unknown age. The factor of unknown age was caused by anglers neglecting to fill in creel census cards properly.

It is known that all fishermen did not fill out the creel census cards from which most of the above information was gathered. Periodic checks of individuals and their catches provided a basis for purely an estimate of 2,000 rainbow trout removed during the 1949 season. There were honest sportsmen on the lake but there were also individuals with more than their share. Since provisions for a checking station were not made, the actual catch can never be known.

Little Granite lake still remains an experimental lake with relatively little known about the most desirable fish management policies. There must be an adequate yearly harvest of rainbow trout and replacements must be planted according to what the lake will support. There is much to be learned but the opportunity is there and we shall attempt to read nature's book.

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mjt
1/13/50

A Comparative Study of the Bottom Fauna Productivity of the North and South Forks of the Provo River at Stewart's Ranch, Utah

by
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Iowa State College, Ames
and
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University of Utah, Salt Lake City

The original purpose of this study was primarily to obtain a qualitative and quantitative measure of the invertebrates on the bottom of the North and South Forks of the Provo River at Stewart's Ranch with secondary reference to the various physical and chemical conditions which influence such productivity. During the course of the survey it became evident that there was a vast difference in the productivity of the two forks of the river. A special effort was therefore made to determine which ecological factors were responsible for this difference. This special aspect of the survey was started in September 1947 and has been conducted on a monthly basis since that time.

Little specific information is available concerning the physical, chemical, and biological factors which influence the productivity of mountain streams. Since 1900 a considerable amount of information has been accumulated dealing with the productivity of standing water, but knowledge concerning streams and rivers is incomplete. In the Intermountain region many miles of high-altitude streams were surveyed during the early and middle thirties by various government agencies, but the bulk of such surveys were conducted during the summer months only and the information accumulated contained rather limited ecological data.

Description of the North and South Forks of the Provo River

The North Fork of the Provo River originates in several mountain lakes in the high Uintah mountain area of Eastern Utah, approximately 15 miles northeast of the area in which this study was made. During the course of its descent from the Trial Lake area to Stewart's Ranch, a drop of about 2800 ft., the river passes over several falls and through an area composed largely of relatively insoluble quartzite mixed with a small amount of shale. The South Fork originates in the Wolf Creek Pass area to the southeast and has a fall of 2400 feet during its course of 7 miles. Its drainage area consists largely of Mississippian limestone. After joining at Stewart's Ranch the two forks form the main part of the Provo River which flows southwestward to Deer Creek Reservoir, a distance of approximately 18 miles.

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1. This investigation has been aided by a grant from the Research Council of the University of Utah.

Both forks are typical swift mountain streams. The average gradient in the North Fork in its 15 mile course is 3.53 feet per 100 feet of stream while in the 7 mile course of the South Fork the gradient is nearly twice as great being 6.46 feet per 100 feet. However, in the area of Stewart's Ranch the gradient in the two streams is more nearly similar, the fall in the North Fork being 1.8 feet per 100 feet of stream, while in the South Fork the decline is more gradual being only 1.28 feet per 100 feet. The width of each stream varies considerably during its course, but in the vicinity of Stewart's Ranch the North Fork is wider averaging about 35 feet throughout most of the year. By comparison the average width of the South Fork is approximately 24 feet.

In many places in both streams the water passes over large boulders, but for the most part the stream bed in both forks is composed of rubble or coarse gravel. At the sampling station the stream bed in the North Fork is principally rubble, being composed of rough irregular stones ranging in size from that of an egg to that of a boulder a foot in diameter. The stream bed of the South Fork at that location is principally coarse gravel mixed with silt. Investigations conducted in other parts of the country indicate that the type of bottom found in the North Fork should be more productive than the gravel type bottom found in the South Fork.

Methods

A series of nine observations at each fork was made between September 17, 1947 and August 25, 1948. All of these measurements were taken between 9:00 A.M. and 1:00 P.M.

The fall, width, depth, and direction of flow in each stream were determined by means of a surveyer's transit and stadia rod. Stream velocity and volume were determined using the formula of Hazzard ('35). Temperatures were taken 6 inches below the surface with a tested chemical thermometer. Hydrogen ion concentrations were determined colorimetrically using a La Motte set. The unmodified Winkler method was used for the determination of dissolved oxygen. Free carbon dioxide was determined with N/44 sodium hydroxide and phenolpthalein, while the bound form was determined by means of N/50 sulfuric acid, phenolptalein, and methyl orange.

Square foot samples were taken by use of a Surber square foot sampler. This sampler consists of a bag made from coarse mesh bolting silk mounted upon a vertical brass frame. The latter is attached to a horizontal frame enclosing an area of one square foot. Samples were taken by placing the net on the stream bottom with horizontal frame pointing upstream. Each time from one to three samples were taken at random from each stream. The organisms were transferred to gallon bottles, and taken to the laboratory for study where they were separated to orders, counted, and weighed. Identification to families and in many cases species was latter carried out.

Physical and Chemical Conditions

The average temperatures in the two forks of the river at Stewart's Ranch showed little difference; the annual average in

the North Fork being 4.8°C while that in the South Fork was 5.1°C, or 0.3° higher. The seasonal fluctuation in the North Fork was slightly greater than the South Fork, the lowest temperature recorded being 0.5° C during the November, January, February, and March inspections, while the highest, 14.5° C, was recorded on August 25, 1948. The lowest temperature encountered in the South Fork was 1.0° C during the November and January observations, with a high of 13.5° C occurring on August 25, 1948. However, these temperatures do not show the entire picture as a thick ice sheet covered the North Fork almost entirely from late December to late March while only the edges of the South Fork were frozen over during this time. The annual average temperatures in both forks are considerably lower than the 8.8° C average reported for Boulder Creek, Colorado by Pennak in 1940 in a similar study.

Great variations in velocity are characteristic of most mountain streams, and while the North Fork proved to be no exception, the South Fork showed considerable uniformity. The average velocity in the former was 3.41 feet per second with a low of 1.45 ft. per second being recorded on December 6, 1947 and a high of 7.63 ft. being taken on June 9, 1948. On the latter date as could be expected, the water was very turbid and considerable molar action was in evidence. The average velocity of the South Fork was 2.61 ft. per second ranging from a low of 1.89 ft. per second on September 17, 1947 to a high of 4.27 ft. on June 9, 1948. The turbidity in this fork on the latter date was not markedly increased. The volume of water in the North Fork during the period of this study was determined for the September 17, December 6, and June 9 observations only with a low point of 22.7 cubic feet being recorded on December 6, 1947 and a high point of 478.4 cubic feet on June 9, 1948. Thus there was a fluctuation of 455.7 cubic feet between these two dates. The volume of the South Fork varied from a low of 28.29 cubic feet on September 17 to a high of 98.34 cubic feet on June 9, for a difference of 70.05 cubic feet.

The waters of both forks were always slightly alkaline, the range being between 7.0 to 8.2. However, the North Fork was more nearly neutral with a range between 7.0 to 7.7. The latter pH was obtained on March 22,1948 after a period of three months in which an ice cover was present. All other readings for this fork were 7.0 to 7.2. The pH in the South Fork had a range between 7.7 and 8.2. The low figure was recorded on June 9, 1948 during high water with all other readings being between 7.9 to 8.2.

The amount of free carbon dioxide in solution in both forks was at all times low. As could be expected the constant agitation of the water prevented the retention in solution of all but a small amount. During the investigation the free carbon dioxide ranged from 0.5 to 1.5 ppm in the North Fork with most of the determinations being around 1.0 and the average being 1.14 ppm. In the South Fork no free carbon dioxide was recorded for four of the nine measurements. The average in this fork was only 0.33 ppm with a range between 0.0 to 0.75 ppm.

The dissolved oxygen concentration in both forks at all times was essentially 100%. The average in the North Fork was 10.0 ppm with a low of 8.1 ppm being recorded on August 25, 1948 and a high

of 11.2 ppm on December 6, 1947. The average in the South Fork was only 0.2 ppm lower, being 9.8 ppm. There the range was between 8.1 and 11.0 ppm with the low occurring on August 25, 1948 and the high on December 27, 1947.

The one outstanding chemical difference in the waters of the two streams involved the amounts of bound carbon dioxide. No half-bound carbon dioxide appeared in either fork at any time but the carbonate content of the two forks showed a vast difference. The average carbonate content of the North Fork was 24.9 ppm with a range between 18 to 29 ppm. Thus the waters of this fork from this standpoint can be classified as being soft. By comparison, the average carbonate content of the South Fork was almost six times as great being 145.6 ppm with a range between 139 to 154 ppm, thus classifying this stream as hard water. This chemical difference can be explained on the basis of the geology of the two drainage areas. The low carbonate content of the North Fork could be expected considering its quartzite basin, while the limestone basin of the South Fork could be expected to contribute considerable calcium carbonate to the water. This difference in carbonate content between the two forks correlates closely with the difference in productivity and is substantiated by work done in other sections of the country. According to Needham 1938 "natural waters showing strongly alkaline (pH) values and those rich in carbonates, bicarbonates, and various allied salts, are well known to support greater amounts of trout foods than acid waters."

Biological Data

The great majority of the bottom organisms collected in both forks belonged to five orders of insects, namely, Trichoptera, Diptera, Ephemeroptera, Plecoptera, and Coleoptera and to one order of Arachnids, the Hydracarina. The total number of organisms found in all of the samples taken from the North Fork was 1252. Of this total Trichoptera constituted 27.47%, Diptera 20.45%, Ephemeroptera 16.85%, Hydracarina 12.78%, Coleoptera 12.69%, Plecoptera 7.19%, Tricladidae 2.31%, Oligochaeta 0.08%, Teleodesmacea 0.08%, and Collembola 0.08%. Although 32 families were identified from these samples the great majority of individuals belonged to only a few families and even to a few genera and species. Thus, most of the Trichoptera larvae belonged to the families Brachycentridae and Leptoceridae; most of the Ephemeroptera were Ephemerella; most of the Diptera were Tendipedinae; all of the Coleoptera were Elmidae and Dryopidae; and most of the Plecoptera were Perlidae and Chloroperlidae.

The total number of organisms taken from the South Fork was 2416. Of this total Trichoptera constituted 41.17%, Diptera 21.96%, Ephemeroptera 19.44%, Plecoptera 9.60%, Hydracarina 5.50%, Tricladidae 1.11%, Coleoptera 0.99%, Teleodesmacea 0.29%, Oligochaeta 0.24%, and Nematoda 0.04%. This collection represented a total of 35 families but as in the North Fork the great majority of individuals belonged to a comparatively few families and genera. Thus most of the Trichoptera larvae belonged to the families Brachycentridae, Limnephilidae, and Hydropsychidae; most of the Diptera were Tendipedinae; most of the Ephemeroptera were Ephemerella; most of the

Plecoptera were Pteronarcella, and the other orders were represented by not over four families each.

Using the standards of Hazzard ('35) for grading the productivity of the two streams considerable difference was shown to exist. According to these standards a Grade 1 (exceptionally rich) stream has in excess of 50 bottom organisms per square foot these having a weight of more than 2 grams; a Grade 2 (average rich) stream has in excess of 50 bottom organisms per square foot but these weigh only from 1 up to 2 grams; a Grade 3 (poor) stream has less than 50 organisms per square foot with a weight less than 1 gram. By these criteria the North Fork rated poor for 7 of the 9 surveys, while the South Fork rated exceptionally rich for 6 of the 9 observations. On the other occasions both streams rated as average in richness.

The average number of organisms per square foot taken from the North Fork during the year was 139.1, these having an average weight of 0.5 gram. Thus this fork, while having over twice the number of organisms necessary to qualify as a Grade 1 stream, must be classified as low in productivity due to the small weight represented. The average number of organisms per square foot collected from the South Fork during the investigations was 268.4, with an average weight of 3.7 grams. Thus this fork easily qualified as being an exceptionally rich stream both from the standpoint of numbers and weight.

SUMMARY

The North and South Forks of the Provo River at Stewart's Ranch, Utah were studied between September 17, 1947 and August 25, 1948 with particular reference to the physical and chemical factors which were correlated with the vast difference in the productivity of invertebrate animals which exists in the two streams. Nine series of determinations were made in each fork during the period of study. A total of 1252 bottom organisms was collected from the North Fork. Of these 90.24% were immature Caddis Flies (Trichoptera), Flies (Diptera), Mayflies (Ephemeroptera) and immature and adult Mites (Hydracarina) and Beetles (Coleoptera). The total number of bottom organisms taken from the South Fork was 2416. Of this total 92.17% were immature Trichoptera, Diptera, Ephemeroptera, and Plecoptera. The average number of organisms per square foot taken from the North Fork was 139.1, having an average weight of 0.5 grams. The South Fork produced an average of 268.4 per square foot with a weight of 3.7 grams. By the standards of Hazzard ('35) the North Fork rates as a stream poor in productivity while the South Fork can be rated as exceptionally rich.

Throughout the course of the investigations the temperature, dissolved oxygen, and free carbon dioxide content were so similar that these factors could not be considered as significant in explaining the differences in productivity between the two streams. The differences can be explained on the basis of the nature of the stream bed, the velocity, the volume, the pH, and the carbonate content of each stream. The significant variations in the two streams are shown in the following table.

Physical Factors

	Velocity (ft. per sec.)		Volume (cu. ft. per sec.)		Stream Bed
	Min.	Max.	Min.	Max.	
North Fork	1.45	7.63	53.60	478.40	Rubble
South Fork	1.89	4.27	28.29	98.34	Coarse gravel and silt

Chemical Factors

	pH		Calcium or Magnesium Carbonate Content (ppm)		
	Min.	Max.	Min.	Max.	Average
North Fork	7.0	7.7	18	29	24.9
South Fork	7.7	8.2	139	154	145.6

Thus it can be concluded that in these two streams greater variability of velocity and volume, the type of bottom, lower alkalinity of the water, and low carbonate content can be correlated with low productivity in the North Fork, while a greater uniformity in velocity and volume, a different type of stream bottom, higher alkalinity of the water, and high carbonate content can be correlated with the high productivity in the South Fork.

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TRENDS IN WISCONSIN FISH MANAGEMENT

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A review of the general evolution of the present fish management program in Wisconsin will, no doubt, parallel to some degree that of other states of our country. The importance of a sound fish management program to the present and future social and economic aspects of our state becomes evident when we outline the extent of the physical or geographic features composing the habitat of the 149 recognized species of fish in Wisconsin waters.

Of the 56,000 square miles of area in this state, 1,680 are covered by water. This is approximately 1,075,200 surface acres of water contained in 8,289 listed lakes and 1,460 trout streams. If you will visualize turning some one and a half million fishermen loose in this tremendous fish farm you will begin to sense the magnitude of the task of regulating and managing the fish crop in any semblance of an intelligent and effective manner. This great army of fishermen is the principal factor on which is based a statewide tourist industry estimated at $300,000,000 annually.

With these facts in mind as illustrative of the current situation, let us consider for a moment the status of the early Wisconsin fishery. The original distribution of the native species of fish in Wisconsin waters was determined by drainages and changes in drainages resulting from glacial movements and processes. The best published report available on this original distribution is that of the Dr. C. W. Creen published in 1935 under the direction of the Wisconsin Geological and Natural History Survey. A study of this report will soon show you that as a result of interference by man, the past 75 years has brought about great changes in this distribution.

A review of Wisconsin history reveals that its many lakes and streams have always been famous for fishing. Before the coming of the white man, they provided an abundance of food fishes for the Indians.

With the coming of the early white settlers and the gradual development of Wisconsin into a great agricultural and industrial state, the drain on this natural resource soon had its effect and many citizens saw need for controlling its exploitation.

The territorial government in 1839 passed what was probably the first statutory regulation in the state for protection of a natural resource. This law required that fishways be put in every dam except mill dams. Other regulations were made including the outlawing of gill nets in 1853 and in 1858 the establishment of a closed season of four months each year on the taking of brook trout with a requirement that they be taken only by hook and line and not be sold. Prior to 1872 the conservation of fishery resources consisted of regulations only. In that year $500 was appropriated by the legislature for the introduction and propagation of fish. In 1874 three fish commissioners were appointed by the governor to receive and distribute fish spawn from the Federal Bureau of Fisheries, and in 1875 the first Wisconsin fish hatchery was established.

With the expansion of artificial propagation in Wisconsin the number of state fish hatcheries increased from one in 1875 to 33 in 1940. Production and distribution of fish increased from 8,000,000 in 1877 to 1,529,208,004 in 1940.

Thus, we see in the steady expansion of the artificial propagation phase of fish management an effort to remedy the destructive effects of natural predators, disease, winter kill, pollution, denuding of watersheds, erosion and many other damaging factors. It was expecting too much of a single remedy.

Nevertheless, had the Conservation department and the early fish-culturists been able to carry out a program of restocking without interference, no doubt fishing conditions in many waters would be better than they are today. The fact is, however, that throughout almost the entire period from 1875 to 1940, fish were stocked indiscriminately on the basis of public demand and request.

From 1881 to 1895, for an example, in response to popular demand, there was widespread propagation and stocking of carp in our waters by both state and federal agencies. Had there been a policy in effect at that time prohibiting the stocking of exotic species, think what a different situation we would have in the waters of southern Wisconsin today!

Think what a better situation we would have in some of our northern Wisconsin musky waters had northern pike not been introduced - only to crowd out the native muskellunge!

Think how much better the fishing for the larger game species would be had crappies not been stocked indiscriminately in many waters!

Think of the splendid bass fishing you might have in some of our small soft water lakes had walleyes not been introduced!

These are examples of the detrimental effects resulting from stocking of fish on popular request and public pressure, instead of management based on factual information concerning environmental conditions.

In 1937 a fishery biology division was established as a means for scientific fact finding in connection with Wisconsin fish management. Work with this division soon engendered in the majority of fishery workers a consciousness of the need for general as well as technical fact finding in evaluating the then current practices in fish management and in directing the future stocking and other fish management practices toward the goal of maintaining the greatest possible supply of desirable game fish species.

Gradually more emphasis was placed on checking results from stocking practices, and eventually it was learned that fry stocking under certain circumstances, such as in the presence of large panfish populations, did not produce the desired results.

The year 1942 saw the beginning of walleye fingerling production in Wisconsin. The stocking of fingerling walleyes, bass, and muskies soon replaced the fry stocking in many cases, and with excellent results as shown by test netting and hook and line returns. The rearing and stocking of legal sized trout was greatly increased to meet the demands of increasing pressure and provide trout fishing on a "put and take" basis.

Rearing fish to larger size for stocking added to the expense, therefore a much smaller number was produced. The total distribution of 316 million fish of all species in 1948 was in sharp contrast to the one and one-half billion production of 1940 when emphasis was being placed on stocking quantities of fry.

Our experience over the past years in the light of an improved fact-finding program has taught us that the immediate need in the propagation phase of fish management is not expansion, but a more selective stocking program to avoid indiscriminate and unwise stocking practices.

As a method of fact finding, lake and stream surveys became standard procedure; intensive surveys for specific problems, and reconnaissance surveys for more general data with application in a greater number of cases.

From this new emphasis on research, or fact finding, both technical and non-technical, on study of results of our fish management practices, there is evolving a better understanding of the real fish management needs of Wisconsin waters. In general the aim now is not to attempt to increase fertility and productivity but to adjust the populations in favor of the more desirable game fish species sought after by the million and more hook and line fishing enthusiasts of our state.

Research has shown that even though we do not apply established fish management practices on a given body of water, natural controls are in effect. Under such natural cycles an undesirable species of fish might dominate the populations of a given lake for many years and the lake thus would have little value to the sport fishermen.

On the other hand, the application of various fish management practices can shorten the cycle wherein the undesirable species is dominant and restore a more desirable species population. Thus, our fish management practices, whatever they be, must be designed to assist nature in maintaining a dominance in the populations of desirable game fish species if we are to secure maximum results from our management efforts.

Research has shown that the lack of results from stocking in many instances is due to lack of proper habitat. There is growing appreciation of the need of habitat improvement through elimination of pollution, restoration of bank and watershed cover, flood control, and prevention of soil erosion as well as control of undesirable fish populations.

Fact finding without application to our fish management problems produces no results. In order to correlate facts with the stocking program, a quota system was established in 1938 whereby various factors such as acreage of lakes, miles and width of trout streams, type of water, species of fish present, and fishing intensity were taken into consideration when allotting fish to public waters. This information was assembled and evaluated by a representative of the fish propagation section, the biology section, and the local conservation warden of the county involved.

This system gradually developed into our present day "fish management meetings" attended by the previously mentioned individuals and in addition the county representatives of the conservation congress as well as interested sportsmen representing conservation groups.

Wisconsin takes pride in its democratic system of granting the sportsmen a voice in recommending regulations for managing its wildlife resources. This system is embodied in the Wisconsin conservation congress and its guidance is not without its problems.

In the early days of the quota system and fishery research, it became evident that there were two ways to satisfy an individual who requested the wrong species of fish for stocking a particular water. His request could be granted with damaging end result or by proper and adequate explanation of the facts involved he could be convinced that his request was not sound. In like manner, the conservation congress representatives, who are sportsmen and laymen from all sections of the state, must be guided and educated in the technical phases of fishery management and the major portion of this task falls upon the fishery research section. It is not always as easy or simple as one might suppose.

The conservation congress has now initiated a committee system with special groups selected to study specific phases of the conservation program. Committees such as the "Trout Committee", the "Fur Committee", the "Fish Committee" and "Waterfowl Committee" act in an advisory capacity to the Congress Executive Council. These groups can be very helpful.

In the fish management field, this democratic system has been taken a step further and the county conservation congress representatives are now invited to attend an annual fish management meeting in company with their local conservation warden to discuss with fisheries research and other field personnel the status of the waters of the county, proposed stocking quotas and other recommended fish management plans.

You may rest assured that it is very difficult to establish quotas and to plan management procedures in this manner since departmental personnel must be adequately supplied with basic facts if they are to convince the attending sportsmen that such proposed practices and plans are sound and if they are to merge the conflicting opinions of these sportsmen into a unified and proper plan of fish management.

In order to substantiate our actions and decisions in making regulations and planning various management programs we must gather facts on aquatic habitats, fish populations and harvests. Immediately we are edging into the field of fishery biology and research. True management must be based on facts and must therefore be founded on research as such. Fish management in the true sense of the term is a new profession, comparatively speaking. From 1839, when the first recorded regulation affecting the Wisconsin fishery was passed, to 1937 when a fishery biology section came into being, research in that field in Wisconsin was practically unheard of, the entire emphasis having been placed on regulations and on general stocking. This period of approximately a century is in sharp contrast to the period of 12 years that has elapsed since the inception of fishery research in 1937.

In Wisconsin we have found, as no doubt, other states have, that there is a difference between pure research and applied research, the former being a fact finding proposition and the latter a combination of fact finding and selling, with plenty of emphasis on the selling. No doubt you have also found, as we have, that this selling begins at home. In 1937 and for some years thereafter many a hatchery man looked down his nose at the fishery biologist and grumbled, not always under his breath. Likewise many a law enforcement officer assisting in the distribution of fish had difficulty in revising his thinking in line with some of the recommendations for more selective stocking. Until our own personnel were sold on fish management, it was not reasonable to suppose that the department as a whole could do the most commendable job of selling the general public on such matters. Not until recently has our department reached the point of fuller appreciation by all

personnel of the necessity of obtaining the facts and findings furnished by the research group of the divisions responsible for them before speaking in public on such subject.

We could in theory have a knowledge of the best fish management practices in the world and yet not be able to put them into practice on Wisconsin waters because the public would not be educated or sold on accepting such practices. To illustrate this point we might take one phase of our fishery research program for the current year in connection with trout lake conversions. Our field men check a number of small lakes which appear to have possibilities for supporting trout populations and providing excellent trout fishing by first removing, by the use of fish toxicants, the populations of panfish or trash fish which are presently in them and restocking with the desired species of trout. Conditions are found to be satisfactory but because of a very small number of property owners who violently object to being robbed of their panfishing, perhaps they are not interested in trout, no action can be taken. The very commendable practice does not go into effect. A small lake in Washington county is considered at the fish management meeting by the warden and the county conservation congress members and the fishery personnel for poisoning because it is believed to have an overpopulation of panfish. Two weeks later a petition arrives in the Madison office signed by many property owners around the lake requesting the stocking of crappies, bluegills, roach, perch and walleyes. They have heard rumors and are not convinced the situation is as indicated.

We cannot hope to convince the public 100% on any fish management practice. There are too many individual conflicts of interest. Take Chetac lake in Sawyer county. At one time it was a splendid walleye lake. Crappies were stocked. It became a crappie problem lake. Numerous petitions from resorters and property owners around the lake were sent to the conservation department requesting removal of crappies, which were stunted and undesirable to the fishermen. That was several years ago. The department conducted a removal program with the use of nets. The size limit on crappies was removed. The lake was opened to ice fishing. Walleye fingerlings were stocked instead of fry. This past summer the walleye fishing returns from hook and line fishing on Chetac lake have been outstanding as can be shown by statements from individual fishermen and resort owners. Yet, our department has recently received a request from one group of resort owners on that lake to have crappies and bluegills stocked. Their argument is that they have a business built on the crappie fishing and their guests now demand such fishing. They feel that they are losing business and desire to have the crappie and other panfish population brought up. That is only one group on the lake. Another group of people still hold with the original desire and request to have the larger game fish populations restored. Both groups cannot be satisfied. Which should have preference? Sound management plans cannot be reversed every time some selfish individual has a different opinion.

For years all of the lakes in Bayfield county have been open to ice fishing for large game fish species with the exception of the Eau Claire Chain of Lakes which has been closed. Each year petitions are received to have this chain opened to ice fishing and others to have it closed. Should the issue be decided on the basis of the weight of public opinion as represented by petitions or on the basis of fish management? If it is to be decided on the basis of fish management, how can such a decision be made?

We have a backlog of requests from various sportsmen's organizations for the removal of carp from many lakes in the southern part of the state. At the same time we periodically receive complaints from other groups who insist that our

rough fish removal crews are damaging weed beds with their nets and causing damage to game fish populations. They forget that in some of those same lakes a few years previously the carp were so abundant that very few weed beds were in evidence.

No, the public will not stand still while this thing called fish management is crammed down its throat. Try it sometime and see what happens at the next legislative session, and in the meantime watch the petitions roll in. Fish management must be sold to the public. Only in that manner can our fishery research reach the application stage.

We have come to the realization in Wisconsin that our major problems in fish management lie not in hatcheries with their well established techniques and trained and experienced personnel but right out there on our thousands of acres of lakes and thousands of trout streams. A solution can only be effected by a study of the problem source. Therein lies the basis for our trend toward smaller geographical and administrative areas and greater unification and coordination with allied conservation activities; more field men on the ground floor where the problems exist to collect the facts and to mould public opinion in the ways of better fish management, or in other words, to do a job of selling the products of fishery research.

Looking back over the experiences of the years, we find that regulations alone were not adequate to meet the problem. Artificial propagation and stocking alone was not adequate. Fact finding without application was of little value, and habitat improvement in the strict sense of the word is not sufficient of itself. It takes a coordinated program to produce results. Last, but not least, is the very evident fact that a successful program of conservation must have the support of an enlightened citizenry.

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THE ROLE AND VALUE OF BIO-ASSAYS OF TOXIC WASTES IN THE POLLUTION ABATEMENT PROGRAM

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Pollution abatement involves an assessment of the environmental situation brought about by any given pollution, in terms of the harm caused to inhabitants of that environment. Before anything can be done to relieve an evil situation, it is proper to know just what the situation is. There are many criteria of the harmful situation created by pollution, based on physical and chemical assay techniques. Chemical analyses of various constituents of polluted and nonpolluted water supplies are standardized and routine. Some of the more common analyses are those of the dissolved oxygen content, B.O.D., chloride and sulfate ions, and so forth.

But in order to have a means of determining what the possible harmful effects of the pollution may be upon the living beings that dwell in the water supply, bio-assays are needed. The idea of bio-assay is by no means new. Techniques involving living organisms have been used in medical and pharmaceutical practice for many years. Many of these methods have become almost as well standardized and infallible as the more strictly chemical quantitative analysis methods.

Bio-assays using fish or other common aquatic animals have been performed for a number of years. Although some of the early experiments along this line were carefully carried out, and yielded important scientific information, nevertheless there was a noticeable lack of any tendency toward true standardization of techniques. Each experimenter used methods of his own devising and lines of approach of his own choice. The result has been that much of the information recorded in the literature is difficult to interpret, or is inapplicable to present needs and uses.

The need, therefore, became apparent for something like a standardized technique for carrying out bio-assays, using aquatic animals as experimental subjects. Of particular pertinence is the use of fish, and the testing of the effect upon fish of various substances which are involved in stream and lake pollution. Although the effect of pollution upon fish is only one of the manifold effects of pollution, nevertheless it is an important one from many angles, including the vital one of economics. It is only logical and proper that tests of harmful effects upon fish be made by the use of living fish.

As with aquatic animals in general, experimentation of this sort upon fish was lacking in standardized techniques. Along about 1941, this problem became particularly acute to the workers in the toxicity control laboratory of the Atlantic Refining Company, in Philadelphia. At that laboratory, W. B. Hart and his associates were attempting to analyze the effects upon fish of various industrial pollutants, when discharged in varying concentrations into streams. The need for standardized methods soon became apparent. In attempting to devise such methods, Hart was joined by Peter Doudoroff and John Greenbank, who were at that time engaged in stream pollution work in Louisiana.

The upshot of three years of conferences and correspondence was the writing of a manual of toxicity testing by these three men. This manual was privately published and distributed by the Atlantic Refining Company in 1945.

The method as proposed calls for considerable strictness in regard to the species and size of fish specimens to be used. It defines and delimits many other factors of the testing, such as water temperature, number of test animals, and other physical and chemical factors. Probably the greatest emphasis, however, is placed upon the method and mathematical formulae used in arriving at and expressing results. The results of all tests are to be expressed in terms of Median Tolerance Limit (i.e., the concentration of the substance being tested which kills exactly one-half of the fish in a given test lot in a given period of time).

The reasons for this choice of mathematical expression are many, some of them being abstract, but most of them being practical. It is held that this method of expression of results renders practical the comparison of experiments in different laboratories, using different toxic substances. Results are always expressed in terms of a concentration of the substance itself, rather than in terms of percentage mortality or length of time of survival.

Much to the gratification of its authors, this method has had wide acceptance in the laboratories of the country. It is now used as standard routine practice by many experimenters who are working with the effects of pollution upon fish life. It is in the process of being extended to application to other forms of aquatic life, such as Daphnia, and so forth.

Recently a sub-committee on toxicity has been formed within the Research Committee of the Federation of Sewage Works Association. A section of this committee will deal with the development and standardization of methods for the evaluation of toxicity to aquatic life. Dr. Doudoroff is the chairman of this section. Other members include several well-known workers in pollution control.

This committee expects to devise and perfect a complete standardization of methods and techniques for this type of bio-assay. This material eventually will be published in the form of a manual or textbook and will be made available to all interested workers. Thus there will be at hand a means of conducting bio-assays of the effects of the multitudinous industrial waste products upon the aquatic life in the waters into which these products are discharged; and this method will compare favorably in scientific soundness with the established bio-assay methods now used in the medical profession.

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THE EFFECT OF POLLUTION ON FISHERIES

by

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Pollution Defined

The Wisconsin statutes define the term "pollution" as "the contamination or rendering unclean or impure, injurious to the public health, harmful for commercial or recreational use, deleterious to fish or animal or plant life of the waters of the state." As a legal definition, this includes the public health aspect, the recreational aspect, the economic aspect, and the biological aspect since all forms of life which exist in the waters of the state are included.

Basic Types

Basically, polluting materials may appear as organic, inorganic, or biological substances. The principal characteristic of organic substances is the oxygen consuming quality of the material. Under certain conditions, the oxygen consuming quality may become such that the dissolved oxygen in a stream becomes depleted and fish either die or migrate. Many other types of aquatic organisms are also adversely affected at this time. Some inorganic substances are toxic, others appear as deposits on the bottom muds and have an effect upon the physical environment of the community and indirectly upon the fish life present. Biological substances contain bacterial and virus organisms and thus are directly connected with public health. The types of the above-named polluting substances may appear singly or combined, as the case may be.

General Sources

The question might now arise as to what are the actual sources of pollution. They can be briefly classified as the activities of industry, the activities of homo, and the activities of nature. As a general rule, the latter does not present a serious problem. Good soil conservation practices will do much to minimize this type of pollution. It is with the former two that we are most deeply concerned. Industry contributes a long list of polluting substances, the majority of which display a tendency to decrease or deplete a stream of its dissolved oxygen. In sizable quantities, these substances often have serious effect upon the existing biota. The normal activities of homo produce a certain amount of sewage. I am sure we are all familiar with the effect of untreated or partially treated sewage effluent upon a natural stream. The contemporary processes of agricultural fertilization also makes man an indirect contributor to stream pollution through surface drainage from heavily fertilized soil. Although this is not a serious type of pollution as we normally think of the term, it is of considerable importance in those lake areas which periodically have a serious algae nuisance condition and an occasional fish kill produced by waters with high fertility.

Ecology of an Aquatic Community

In discussing the effect of various polluting substances on fisheries, I would like to digress slightly and focus our attention for a time upon the ecology of a balanced aquatic community.

A balanced community contains a great many different species of plants and animals forming a food chain which passes from bacteria through the plankton, many species of invertebrates, and several species of forage fish or minnows, the ultimate consummation of which is in the several species of "fine" fish. Fish are actually the end product of this association. It is necessary that this food chain remain intact and exist in a balanced state if we are to receive the maximum sustained yield from our fishery. The environment must be favorable to the mixed fish population and the chain of supporting organisms. Chemical, physical and biological factors must be suitable for maintaining life at all times if the biological community is to survive in a balanced state.

Substances which change or alter this ecological association produce a noticeable effect upon the existing fish life either directly on the fish themselves or indirectly through the supporting organisms. If conditions become too severe for the existence of a balanced fish population, the game fish will be forced out of the community and rough fish will dominate. A noticeable change will also occur in the bottom fauna at this time. If conditions become too severe for even the rough fish, the community will become seriously altered and instead of a balanced population containing many species of organisms with few individuals each, there will exist a population containing few species but great numbers of individuals. Conditions may become so severe that only the tubificid worms and one or two species of chironomids can exist, or even these may be forced to a bare minimum of numbers. The impact of any substance which alters the environment to the extent that life within the food chain is impeded will ultimately be perceptible within the fish population itself.

Effect on Community

In support of our idea of the effect of polluting substances upon the biota with fish serving as the axis of that aquatic biota, one might classify those substances as to their effect upon the chemical, physical and biological environment. In the chemical category are placed those substances which decrease the dissolved oxygen content of the water and those which alter the pH of the water. It is generally agreed that 5 p.p.m. D.O. is necessary at all times for favorable growth and reproduction among the fish population. Respiratory and circulatory compensations begin in the body of the fish when the D.O. goes below this level. The biochemical oxygen demand itself would not be harmful, providing it is not toxic, if there is sufficient aeration to maintain the D.O. at 5 p.p.m. Since game fish cannot live and reproduce in waters containing less than 5 p.p.m. D.O. it follows that a slight reduction for any length of time would result in a greater abundance of rough fish in the fish population and the ultimate dominance by this group. If the D.O. is reduced to near zero for a short time, all types of fish life will be excluded and tubificid worms will dominate the biota. High B.O.D. and accompanying low D.O. are easily demonstrable in streams bearing the untreated effluent of canneries, cheese factories and paper mills. Optimum pH ranges for fish vary between pH 6.5 and pH 8.4. Waters which range beyond these extremes are definitely

detrimental or even lethal, producing cardiovascular and respiratory disturbances. Acid waters impair the oxygen absorbing power of the gills, reducing and eventually stopping the flow of blood to the gills and vital organs. Alkaline waters dissolve away the protective mucus from the gill filaments thus causing hemorrhages. Examples of these substances are the acid wastes of tanneries, chemical works, and metal working establishments, and the alkaline wastes of evaporator boil-off in milk plants and certain wastes from the canning of vegetables.

Those substances which alter the physical environment are confined primarily to the suspensoids which blanket the bottom of the stream. Suspensoids might increase the turbidity of the water, thus reducing the amount of light penetration and ultimately reducing the amount of plant and animal growth which forms a portion of the food supply of the fish population. They may also blanket the stream bottom and destroy the spawning areas. Thus, it becomes only a matter of time until the fish population becomes removed through lack of natural reproduction. At the same time, these substances smother out the food organisms which live in the bottom muds so that the food supply for those transitory fish which might survive is substantially reduced. Sawdust, wood chips, wash water from gravel washing operations and unrestricted drainage from agricultural lands contribute greatly to these conditions.

Lastly, there are those substances which alter the biological environment of the community. Naturally, all factors have an effect upon the biological community but those substances which are definitely toxic in nature affect the biota directly with almost immediate results. Toxic substances may be toxic to adult fish or various stages in the life history. The younger stages are in general more susceptible to dilute toxicants. There is also a great variation in the reaction to toxicants of the various species which comprise the fish population. Fish swallow a certain amount of water as a normal body function for the formation of urine and in this manner absorb toxic substances very quickly. Dilute toxicants might also be lethal to some organism or organisms in the food chain, the ultimate result of which is the starvation of a portion, or all, of the fish population. Crude oil, chlorine, ether, chloroform, methyl mercaptan, formaldehyde, phenol, and others possess these toxic properties.

Self-Purification

The ultimate outcome of pollution is of foremost importance. In other words, what happens after pollution? As all of us know, fish are given one of two choices depending upon the severity of the polluting substance - they can either move out or die. The stream itself undergoes some very important changes, however, aimed at self-purification. When a large volume of wastes is discharged into stream, there soon develops a zone in which active decomposition takes place. This zone contains a great many individual organisms but few species. The predominant forms are the tubificid worms and other Oligochaeta, and some of the more hardy species of Chironomidae. The organisms that do occur often occur in great numbers and coupled with the tremendous amount of bacterial life in this area serve as digesters of the pollutional load and tend to convert those substances into simple materials which find greater utilization in the economy of the stream. A portion of this zone may become septic in nature. In a septic zone, all of the organisms which are common inhabitants of a clean water stream are eliminated. The D.O. is reduced to zero and about the only forms which exist under these conditions are anaerobic bacteria and the more

hardy forms of pollutional organisms. The zone of active decomposition may extend for miles along the course of the stream but gradually a change develops and a zone of recovery appears. This is characterized by a greater number of different kinds of organisms which tend to further convert the pollutional substances. Some of the more hardy species of fish - usually a rough fish variety, can tolerate the lower limits of this zone. The termination of the zone is into a gradually developed clean water area in which normal fish fauna are once again able to survive. Many miles of good fishing water and good recreational water have been wasted during the course of these events. Biological change is a slow change and many years would be required to convert this complete area back into normal habitat if the source of pollution were removed.

Summary

In conclusion, it might be said that as biologists we are interested in the effects of pollution upon the community as a whole because the community has a direct relationship to the existing fish population. We are interested in the worst conditions taking place in a particular pollution sequence - we are not interested in averages occurring over a period of time. Conditions which exist for only a short period of time may seriously alter the biota. Any substance which affects any stage of the life history of the fish population, either directly or indirectly, will ultimately have a bearing upon fish production. It takes many years to rebuild a balanced community after it is ruined by a short period of pollution.

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IOWA'S TROUT PROGRAM

R. B. Cooper
Superintendent of Fisheries
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Presented at the 11th Midwest Wildlife Conference on
December 15-16-17, 1949, Madison, Wisconsin

Trout have been cultured in Iowa since the first state fish hatchery was established at Anamosa in 1873. In 1880 a hatchery was constructed on the isthmus between Spirit Lake and East Okoboji Lake; and trout and eggs were transferred from Anamosa to the new site. Fish; including Atlantic and California salmon, lake trout and brook trout were stocked in virtually all of the important lakes and streams in the state for many years. Although considerable success attended the efforts of the pioneer fish culturists in establishing certain non-native species of trout in the spring fed streams in northeast Iowa, it soon became apparent the trout stocking efforts elsewhere in the state were futile.

In 1918 trout hatchery equipment was installed at the Lansing fish rescue station. From that date until 1928, all of the trout for stocking in Iowa were produced at this station. During this time trout were released to the wild in the fry and fingerling stages. The Lansing hatchery was discontinued about 1931.

The Backbone trout hatchery was established near Strawberry Point in 1925, and the first distributions were made in 1928. A few adults were released in 1929, but the majority of the fish were stocked as advanced fry and fingerlings. In 1933 all the fish released were over seven inches in length.

In 1931 an extensive survey was made of all potential trout streams in northeast Iowa, and a list of all suitable trout waters was compiled. Most of the streams have been analyzed several times, and all of the trout waters in the state have been classified according to their value and the fishing pressure exerted upon them.

The policy of the commission is to stock such streams that will support trout throughout the entire fishing season. Many factors are considered in the biological evaluation of a good trout stream. They include temperature, volume of flow, tributary springs, gradation, velocity, color and turbidity, alkalinity, pools and shelter, riffle areas, shade, aquatic vegetation, fish food, etc. Of these requisites perhaps temperature, volume, cover, and fish food are the most important. Experiments conducted in Iowa and other states indicated that water temperature higher than 75° F. is generally fatal to brook trout, while brown and rainbow trout may endure temperatures as high as 80° F., providing the stream has good gradation and volume.

Trout streams are stocked in advance of the open season and several times during the course of the year. The number of fish stocked and the frequency of stocking depends upon the classification of the stream, and the number of trout available for distribution.

Most Iowa trout are stocked during April, May and June, when the streams are at their best. During the hotter months of July and August, only the major streams are stocked; then from September till the end of the trout season (November 30) all streams receive additional fish.

During the 1949 open season approximately 200,000 trout, ranging from 7 to 12 or more inches in length, were released. Each year 15 to 20 thousand of the smaller yearlings are held over for the next season. These fish grow to a length of 12 to 14 inches in length and are mixed in with the 7 to 10 inch yearlings at distribution time, thereby giving each stream its proportionate share of larger fish.

Checks are made in many of the streams during the winter months with an electric shocking machine to determine the carry-over population, thereby helping to evaluate each stream.

Iowa's 44 trout streams are in the so called "Driftless Area" in the northeastern corner of the state. The good trout streams arise in clear springs from the limestone bluffs which line the valleys and are found largely in Winneshiek, Allamakee, Fayette, Clayton and Delaware counties. Erosion control is very important in this area, to lessen the amount of soil being washed into the streams, where it fills up the holes and levels off the bottom, smothering out the natural trout food. It is of paramount importance that soil conservation measures be taken in the immediate future if these streams are to be preserved for this and future generations as trout waters.

Iowa has approximately 250 miles of trout water, receiving 200,000 trout annually or 800 fish per mile per year.

Table 1

A Financial Statement of the Iowa Trout Program by Stations in 1948

Labor	Dry Feed	Carp & Meat	Drugs	Electric Power	Tele-phone	Main. & Misc. Depre.	Trucks Distrib.	Fuel
Backbone Hatchery, Strawberry Point								
6,072.00	2,566.83	6,103.53	26.39	420.00	124.85	966.04	2,613.00	92.28
Decorah Hatchery (Subsidiary)								
3,997.00	578.68	2,965.14	120.31	156.87	29.07	206.97	2,268.80	33.80
Total Cost Both Stations								
10,069.00	3,145.51	9,068.67	147.20	576.87	153.92	1,173.01	4,831.80	126,08

Total expenditures of Backbone hatchery	$18,987.42
Total number of trout stocked from Backbone hatchery	156,000
Cost per trout stocked from Backbone hatchery	12.17¢
Total expenditure of Decorah hatchery	$10,356.64
Total number of trout stocked from Decorah hatchery	44,000
Cost per trout stocked from Decorah hatchery	23.53¢
Average cost per trout stocked from both hatcheries	14.67¢ per fish

The above figures show the cost per trout at the Decorah Hatchery to be twice as expensive as the fish produced at Backbone Hatchery. It should be explained the Decorah Hatchery is a subsidiary station on our trout program and the amount of suitable water is limited. The primary purpose of the station is to propagate smallmouth bass. If sufficient suitable water was available, it would be possible to increase the output of trout with very little additional expense, thereby, reducing the over all cost per trout.

TABLE II

Food Table for 2,000 pounds supply of dry ingredients	Guaranteed analysis of 32 per cent supplement mash	
20% or 400 lbs. 32% supplement mash	Protein, Minimum	32.0%
30% or 600 lbs. flour middlings	Fat, minimum	4.5%
30% or 600 lbs. Red Dog flour	Fiber, maximum	6.5%
10% or 200 lbs. cottonseed meal	Calcium, maximum	6.0%
10% or 200 lbs. rolled oats	Phosphorous, minimum	1.5%
	Salt, maximum	2.0%

Ingredients: Vitamelk Base, which contains Fermentation Solubles (Rich Source of Vitamin B Complex), Soybean Oil Meal Flour, Liver Meal , Fish Meal, Beef Meal, Dried Whey, High Lactic Dried Buttermilk, Milk Albumin, Dried Yeast, Wheat Embryo, Special Dehydrated Alfalfa Leaf Meal, Riboflavin Concentrate (High Potency Vitamin G), Fish Oil Blend (High Potency Vitamins A & D), Oil of Wheat Embryo (Rich in Vitamin E), Fish Oil Concentrate (Vitamin A), Chick Vitamin D_3 Oil, Animal Vitamin D_2 Oil, Carotene (Pure Pro-Vitamin A), Ascorbic Acid (Pure Vitamin C), Menadione (Vitamin K), Thiamin Chloride (Pure Vitamin B_1 of Vitamin B complex), Niacin (Pure Factor of Vitamin B Complex), Choline Chloride (Factor of Vitamin B Complex), Methionine, Ca. Pantothenate (Flitrate Factor of Vitamin B Complex), Biotin (Vitamin H Factor of Vitamim B Complex), Pyridoxine (Pure Vitamin B_3 Factor of Vitamin B Complex), Di-Calcium Phosphate, Manganese Sulfate 0.30%, Iron Sulfate 0.10% Sulfur 0.02%, Copper Sulfate 0.01%, Potassium Iodide 0.01%, Wheat Middlings, Wheat Bran, Meat Scraps, Alfalfa Leaf Meal, Soybean Oilmeal, and Fish Meal.

TABLE III

Total Food Consumption to Produce 200,000 6 oz. Trout	
Dry foods	66,500 lbs.
Beef melts	55,406 lbs.
Beef livers	15,968 lbs.
Fresh carp	69,000 lbs.
GRAND TOTAL	206,874 lbs.

Table IV

Pounds of Food Used to Produce One pound of Trout for Stocking

75,000 pounds of trout stocked
206,874 pounds of food consumed or
75,000 ÷ 206,874 = 2.75 pounds of food
to produce one pound of trout, at a cost
of 39.11¢ per pound released in the streams.

The dry feed is cooked, then cooled and mixed with beef liver and beef melts. The cooked food and meat are mixed on a ratio of four to one. Fresh ground carp are used as a supplement after the trout are five to six inches in length.

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Fishing Census, Mississippi River

Locks and Dams Nos. 1-10

St. Paul District, Corps of Engineers

Harry E. Adams

Foreword

In cooperation with the Upper Mississippi River Conservation Committee, fisheries section, the St. Paul District, Corps of Engineers has conducted a fishing census between the hours of 2:00 p.m. and 4:00 p.m. each day during the years 1948 and 1949 from each lock and dam, Minneapolis, Minnesota to Guttenberg, Iowa (Locks and Dams Nos. 1 through 10). Only one daily observation is made by each lockmaster. He counts only those fishermen and boats within eyesight and, in addition, determines the number of sport fishermen as compared to commercial fishermen. This information is helpful to the committee mentioned above in analyzing total fishing pressure in this section of the river. It also provides an index of the fishing pressure experienced in the vicinity of the locks and dams.

Sport Fishermen

Sport fishermen compose the bulk of those engaged in taking fish at the locks and dams. A grand total of 41,599 were counted in 1948 and, although the December records for the year 1949 are not as yet compiled, the number this year has risen to 56,045 through November. This indicates an increase of over 37 per cent in fishing pressure. Practically all fishermen fish below the locks and dams where fish are concentrated against the current. Very few try their luck above the structures. In order to preserve life and property, all fishermen are warned to stay at least 300 feet from the damsand to keep clear of the locks. Several drownings and near drownings have occurred as a result of a few fishermen who disregarded this warning.

Commercial Fishermen

During 1948, 1,697 commercial fishermen were counted as compared to about the same number for 1949. The commercial fishing pressure, therefore, has apparently remained static during the two years the census has been in progress. From the records it appears that only one in twenty-five fishermen fished commercially in 1948. The difference in 1949 is evidently even greater.

Boats

Sport fishermen in 1948 used 12,837 boats as compared to 730 used by commercial fishermen. This indicates that one boat was used by about 3.2 sport fishermen, and one boat for 2.3 commercial fishermen. From the records compiled so far for the year 1949 the same ratios as indicated above still exist between boats and fishermen. Much fishing is done from floating rafts anchored

below several of the locks and dams. Many fishermen use these facilities which are made available by private interests. Fishing from the rafts affords a great deal of enjoyment and satisfaction to those who either cannot afford to keep a boat in the vicinity of the structures or who are physically unable to handle a boat in the river. Fishing from rafts is not considered as fishing from boats in compilation of these data.

Fishing Seasons

May and June, and September and October appear to be favorite seasons during which both sport and commercial fishermen make a maximum effort to take fish. No doubt the long inactivity of the winter months encourages many people to go fishing at the first opportunity in the spring. Then again the fish are moving at this time and are more apt to be taken by line as well as by net. Later, when cool crisp days of autumn prevail, fish bite exceedingly well and, notwithstanding duck and pheasant seasons, sportsmen make a particular effort to secure a well filled creel (see graph attached).

Fishing Pressure

Fishing pressure is greatest in the vicinity of La Crosse, Wisconsin. Pool number 7, just above La Crosse, ranks highest in sport fishermen with pools 8 and 9 running second and third respectively. That section of the river from Red Wing to Winona, Minnesota attracts many fishermen. In this area pools 3, 4 and 5 are heavily fished but fall short of the pressure exhibited at pools 7, 8 and 9. Commercial fishing also gains momentum further downstream, the greatest number of commercial fishermen being found in pool number 9 above Guttenberg, Iowa. Apparently there are several reasons for this distribution in fishing pressure. The primary reason is the lack of inland lakes below St. Paul. It is either a question of fishing in the river or not going fishing at all for many people. The second reason is probably related to the distribution of fish. All species of fish common to the river seem to increase below lock and dam no. 3.

Conclusions

1. Fishing pressure adjacent to the locks and dams within the St. Paul district, Corps of Engineers, Mississippi river is increasing.

2. Sport fishermen far outweigh in numbers commercial fishermen.

3. The use of boats is very prevalent among all classes of fishermen.

4. Fishing pressure is greatest in the vicinity of La Crosse, Wisconsin.

Attach

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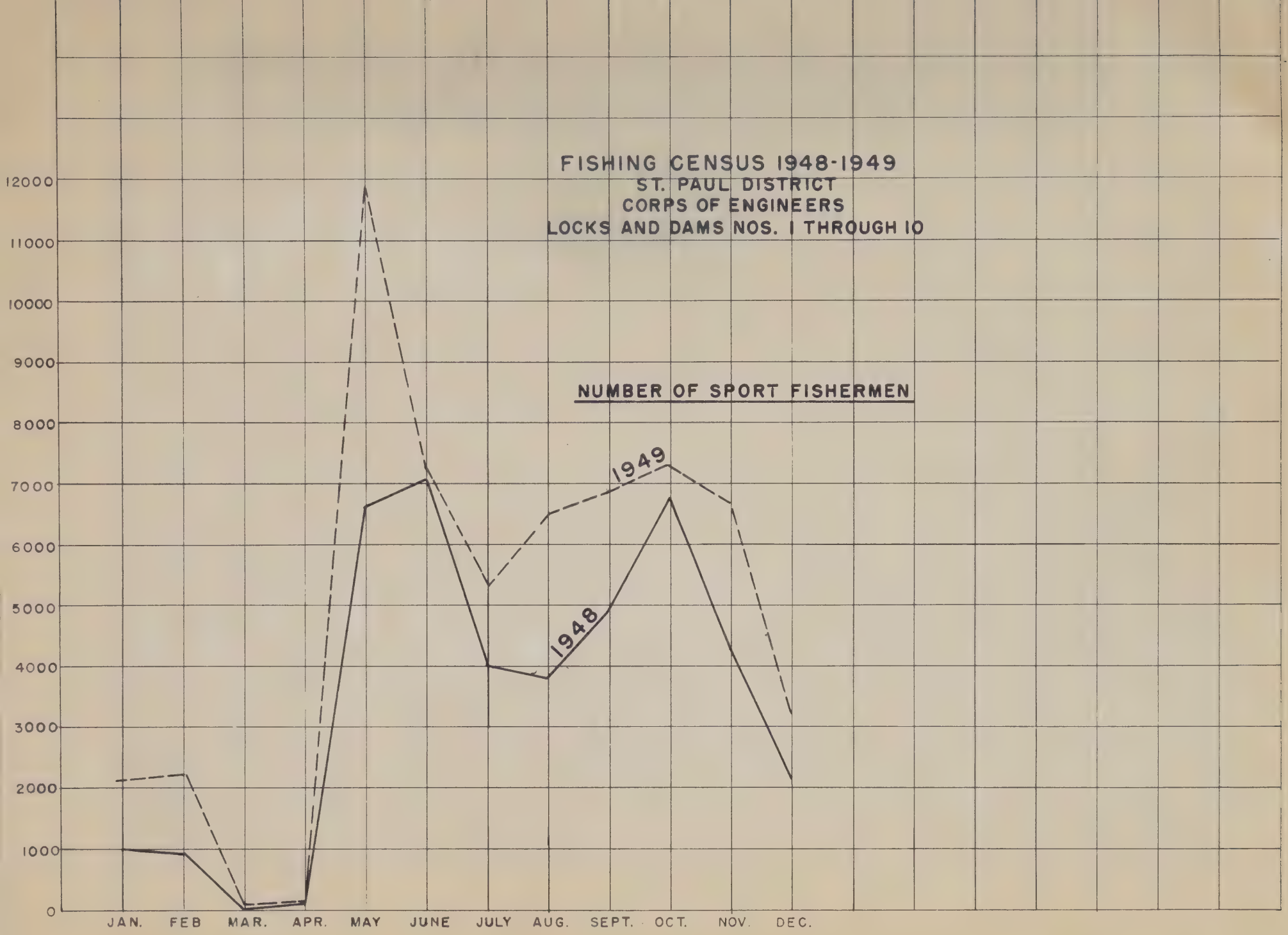
FISHING CENSUS 1948-1949
ST. PAUL DISTRICT
CORPS OF ENGINEERS
LOCKS AND DAMS NOS. 1 THROUGH 10
NUMBER OF SPORT FISHERMEN
1949
1948
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
JAN.
FEB
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
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DEC.

Wisconsin Conservation Department
Madison 2, Wisconsin

Division of Fish Management

Section of Fishery Biology
Investigational Report No. 715

An Analysis and Appraisal of the Rough Fish Problem of Wisconsin

by
C. W. Threinen

December 22, 1949

AN ANALYSIS AND APPRAISAL OF THE ROUGH FISH PROBLEM OF WISCONSIN

C. W. Threinen
Wisconsin Conservation Department

Presented at the 11th Midwest Wildlife Conference on
December 15-16-17, 1949, Madison, Wisconsin

Rough fish, coarse fish, or undesirable fish, are both a problem and a crop to fish managers in Wisconsin, particularly in the southern part of the state. In the general area south of a line extending from the St. Croix river in northwest Wisconsin across the state into southern Marathon county in the central and central Outagamie county on the east and north to encompass Green Bay the problem is most intense (Figure 1). This is the agricultural region of the state.

Throughout this general area most waters have a rough fish (principally carp) problem, and varying degrees of rough fish control are exercised. Some of this control may be described as effective overfishing, and some as continuous yield commercial fishing. The character, results, and analysis of the fishing effort with suggestions for management are the subject of this paper. For fifteen years the Wisconsin Conservation Department has been actively engaged in rough fish management, during which time it has collected complete records. For purposes of this paper these records have been liberally used in combination with a number of personal observations of the rough fish populations and the circumstances under which they are abound.

The discussion will be organized into sections in which (1) the methods of control, (2) producing areas, (3) yield, (4) character of the controlled populations, (5) growth and catchability, (6) effect of the rough fish on an aquatic environment and (7) the management of rough fish populations are discussed.

Methods:

Several methods are used in harvesting the rough fish among which are seines, traps, trap nets, and gill nets. Of these types, seines find most general use in the capture of the common rough fish, but under certain specialized conditions other types of gear are successful.

Before going into detail on the methods of harvest it is well to review the species which comprise the harvest. As it existed in 1948, it is dominated by carp which makes up all but 1,000,000 pounds of the total catch (table I). The harvest of sheepshead follows that of the carp with a total harvest of 637,040 pounds and the buffalo totaled 247,903 pounds. The balance of the catch is comprised of lesser quantities of other species. Since the rough fish problem is so dominated by the carp, this discussion is principally concerned with it.

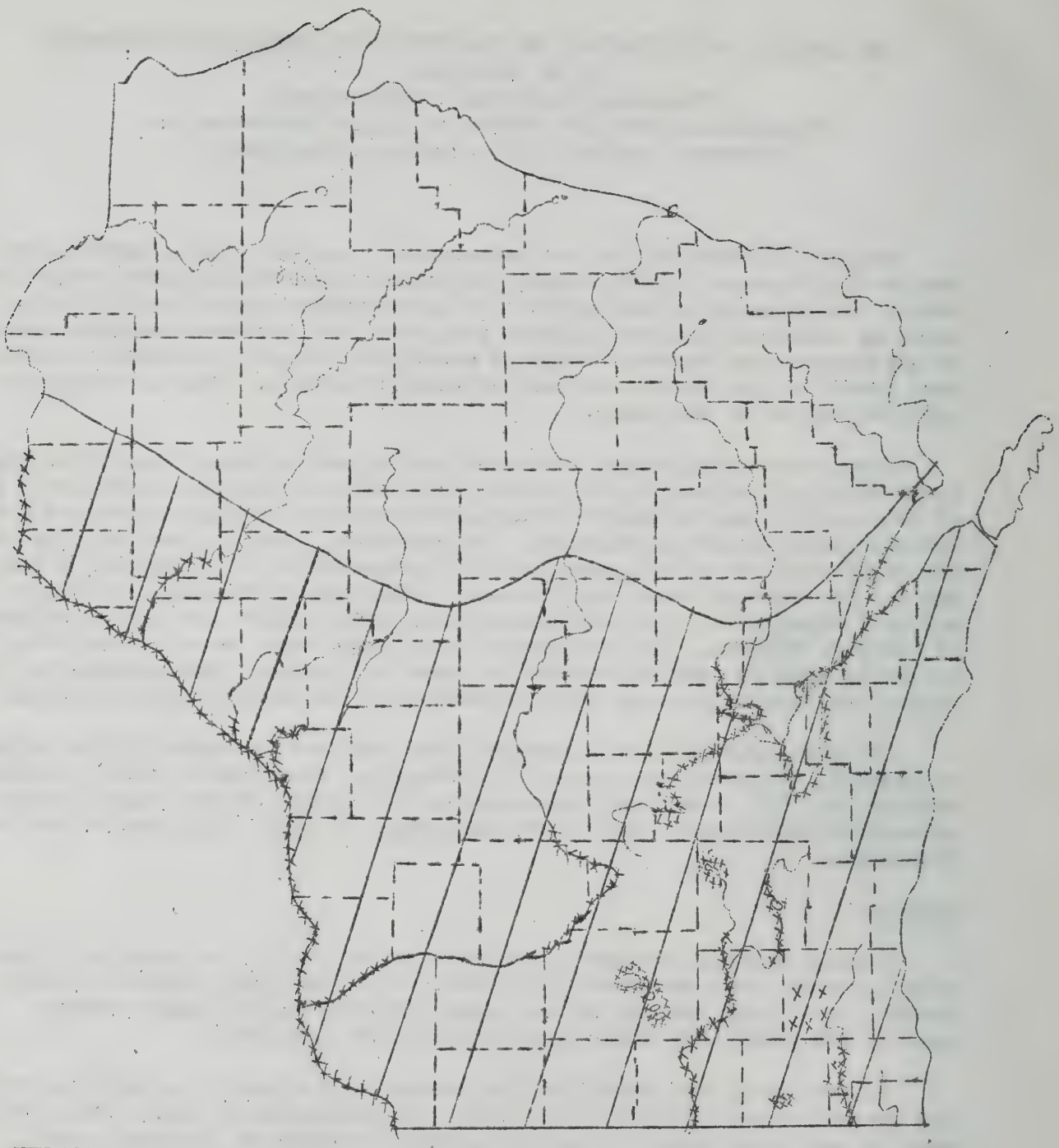


Figure 1 Rough Fish Producing Areas in State of Wisconsin

X Principal producing Areas

Table I

Rough Fish Harvest by Species, 1948

Carp	6,206,345 pounds
Sheepshead	637,040
Buffalo	247,903
White Carp	72,116
Eel pout	36,713
Garfish	34,580
Sucker	16,455
Dogfish	7,120
Mooneye	3,448
Shad	1,100
Total	7,267,114

The use of seines provides the most successful method of capture, an illustration of which appears in Figure 2. The seines may measure anywhere from a few hundred to six thousand feet in length depending on the area that is fished. In the large shallow water areas that permit the use of a large seine, the five to six thousand foot seine finds general use while in the more confined areas such as rivers a short seine measuring from five hundred to two thousand feet is generally used. The seining is usually carried out in those periods of the year when little harm is likely to be done to the game fish or the rough fish, which are marketed alive, and in those times at which the fish are easily caught. It begins just as soon as the ice goes out and continues until the water becomes too warm to crowd the fish into the

Figure 2
Seine haul being made on Lake Winnebago

bag of seine without resulting in death to the fish. It is resumed again in the fall when the water has cooled sufficiently to permit the crowding of fish again, and continues until the winter freeze-up. Sometimes, the fishing can successfully be continued in the winter through the ice, where circumstances are such that the fish become "bunched" in water shallow enough to fish with seines.

The seines used in rough fish control operations are usually three to five inch stretch measure mesh nets which have a bag into which the fish are crowded as the seine is drawn in. The nets themselves are hauled about and disbursed from barges; small pulling engines furnish the power to draw the seine haul. Upon the completion of a haul the fish are run into floating live cribs and subsequently confined to pens before shipment.

As mentioned previously the seining is most successful at certain times of the year which are early spring shortly after the ice breaks, spawning season, and late fall when the fish again "bunch" in shallow water. There are such tremendous concentrations then, that as many as 500,000 pounds of carp have been caught at a single pull of the net. At times other than those just mentioned the carp are generally distributed and caught largely in proportion to their over-all density.

In certain areas a wooden weir is an important method of capture. It reaches its greatest efficiency where there is a narrow neck of water through which the fish are known to move. Upwards of 100,000 pounds a season have been produced in some of the more effective weir traps. These traps, like the seining, are most successful in the early spring, at spawning and in the late fall, periods when the fish seem to move about most. It is unprofitable to operate a weir trap in other periods.

Figure 3
Wooden weir - rough fish trap

The weir as illustrated in Figure 3 is essentially a verticle slat board construction made of either 1 x 4 or 2 x 4 which are set one to two inches apart to form the wings of the lead, the V entrance and the pen. They are particularly successful in rivers and narrow entrances to shallow bays.

Trap nets are seldom employed in catching carp because carp will not follow a lead. This method is most important in Lake Winnebago where there is an extensive sheepshead fishery, and it finds some use where buffalo or quillback are sought.

Gill nets at times are successfully used also, particularly in the winter when sets are made under the ice. The seven to eight inch stretch measure mesh is large enough to permit the escape of the common game fish, but it will take five pound carp. However, the gill nets are neither used as extensively as seines nor do they produce as much poundage.

Along with the discussion of the methods of capture it is timely to give an accounting of the practices of the fishermem in estimating and reporting their catch. The fishing is done by two classes of fishermen, Conservation Department crews and commercial fishermen who are known as contract fishermen. The name contract fishermen is derived from practice of issuing contracts to private operators for the removal and the sale of rough fish which provide that the operator pay a percentage of his gross to the department and hire the services of a warden who shall at all times supervise his fishing effort for the best interests of the game fish populations. Having wardens on the job continously who report the catch of rough fish from both the state crews and the contract operators has permitted the accumulation of a reasonably accurate and continous set of statistics on the rough fish catch. The attending wardens make estimates of the weight of each catch right on the spot at the time of the completion of the fishing effort, and it is these estimates that furnish the basis for these statistics.

There may justifiably be some question about the accuracy of statistics of this type which are only estimates, but as a general rule the estimates of commercial fishermen are regarded as being nearly accurate. At coast ports fishermen's estimates, or "hailings" as they are called, are accepted with no more than five per cent error by the buyers. In the opinion of the department fish broker the error of these Wisconsin fishermen does not exceed this limit either. The ultimate test of the accuracy of estimates made at the scene of the effort can be had by comparing the weights of fish sold with the estimated weight. In such comparisons the two were very similar, hence it can be said that the statistics are reasonably accurate and within limits of five per cent error.

The individual catch estimates are prepared on a form known as the "Supervising Warden's Daily Report" (Figure 4). This report provides for the entry of the total catch of rough fish by weight, by species and by size for purposes of sale, and it also permits estimates of the numerical abundance of the game fish. To the analyst the great value of this report is evident, for it furnishes evidence of the effectiveness of the gear used, it contributes to the study of the yield and by reporting the size of the fish it is possible to trace the dominant year classes through the fishery.

COPY

Wisconsin Conservation Department
Madison, Wisconsin

SUPERVISING WARDEN'S DAILY REPORT

State and Contract Fishing Operations

(This report must be mailed to the conservation department at the close of each day you supervise fishing)

Date October 21 1947

Name of fisherman Wis. Conservation Dept. P.O. Address Fond du Lac
Name of waters fished Lake Winnebago Located in Fond du Lac County
Location of haul
No. of seine hauls made No. of entrapping nets lifted 24
No. of feet of seine operated Size of mesh
No. of feet of gill net lifted Size of mesh

Estimated No. Fish Taken				No. of Game Fish Returned to Water	No. Game Fish Killed
Carp No. 1		280	lbs.	Pike	8
Carp	White	100	lbs.	Black bass	
Carp No. 3			lbs.	Pickerel	1
Buffalo No.1			lbs.	Sunfish	
Buffalo No.2			lbs.	Crappies	
Suckers	Returned	3	lbs.	Bullheads	
Sheepshead		8720	lbs.	Sturgeon	
Dogfish			lbs.	Catfish	
Garfish			lbs.	White bass	
Eelpout			lbs.	Other varieties Perch	1
Total lbs.		9100		Total No.	10

Were fish taken immediately from net for packing and shipment Yes
Were fish placed in live pens Where
Remarks: Dead game fish were buried, Balance of catch were shipped.

Noted:

Division Chief

Signed /s/ Nicholas J. Miller
Supervising Warden

Figure 4. Form on which fishermen report rough fish catches.

To supplement the statistics observations of individual fish populations were made for indices on the character of those populations and the likely effectiveness of control. For this purpose length frequency and growth data were collected. There were also observations made on the environment in which the carp persist for evidence of their effect on environment. These observations and statistics will be combined to furnish the basis for this report.

Principal producing areas and type of localities:

Although the rough fish problem covers the southern half of the state of Wisconsin, there are within that area certain particularly productive waters that furnish the bulk of the total harvest. An enumeration of the harvest from these waters is given in Table II. It can be seen that the 32 bodies of water listed produced. 6,711,250 pounds, 96.4 per cent of the total 1948 harvest in the inland waters of the state.

Table II

Rough Fish Harvest From Principle Producing Waters in Wisconsin. 1948

Lake	Pounds
Koshkonong	1,935,875
Winnebago	600,246
Beaver Dam	556,304
Waubesa and Upper Mud	567,357
Kegonsa and Lower Mud	476,380
Poygan	278,722
Monona	213,045
Chippewa River (Pepin County)	200,344
Rock River (Dodge County)	181,301
Fox River (Winnebago County)	179,500
Rock River (Rock County)	172,450
Wisconsin River (Juneau County)	141,500
St. Croix River (Polk County)	140,945
Cassville Slough (Grant County)	124,434
St. Croix Lake	104,404
Wisconsin	98,341
Bark River (Jefferson County)	91,900
Grand River (Marquette & Green Lake Counties)	75,500
DeSoto Bay (Vernon County)	67,607
Mason	59,575
Black River (La Crosse County)	57,268
Sheboygan River (Sheboygan County)	56,900
Nagawicka	46,065
Beef River (Buffalo County)	40,942
Eaugalle	35,275
Wolf River (Waupaca County)	35,667
Fox River (Brown County)	34,000
Wisconsin River (Columbia County)	33,475
Big Green	29,600
Goose	28,814
Trempealeau Bay (Trempealeau County)	27,204
Mendota	20,310
TOTAL	6,711,250

One of the largest and most consistent producers has been 10,000 acre Lake Koshkonong with a production measuring between 500,000 and 1,900,000 pounds annually for a fifteen year period. This lake is a shallow widespread in the Rock river in Jefferson county having a maximum depth of only 11 feet. In the muddy bays it becomes choked with submerged aquatic vegetation by midsummer. It can be described as typical rough fish habitat.

The bulk of the rough fish are produced in waters of the type described. They are either slow rivers, the meandering widespreads of rivers or shallow lakes. The exceptions are the large deep lakes which have considerable shallow water area and lakes that are heavily fertilized from domestic sources. These waters are typically eutrophic, having a high alkalinity, mud bottoms and extensive development of aquatic vegetation.

Yield:

The production of rough fish can best be compared by reducing the total catch for a particular body of water to a pounds per surface acre figure. When this is done for a number of the waters for which there were accurate acreage figures available, it was found that the yield in any one year of fishing effort ranged from to 5 to 500 pounds per surface acre. This extreme variation in the production of rough fish can be explained by differences in productivity and fishability. To illustrate this point there is reproduced in Table III a list of the pounds per acre yields of a number of waters coupled with the acreages and the depths of these waters.

Productivity appears to be related to water depth because the best production occurred in shallow bodies of water. This can be seen in the ascending order of Table III where the largest production figures originated from waters 10 - 20 feet in depth. Conversely, the deep bodies of water, those over twenty feet in depth, were the poorer producers. Here production is related to the extent of the shallow water area. It can be said that the deep bodies of water produced less than 80 pounds per surface acre and the shallow bodies of water more than 80 pounds per surface acre. There is, however, a great range in the latter group which can be explained in another way.

Table III

Typical Yields of Rough Fish Waters in The State of Wisconsin

Lake	Acreage	Depth	Yield per acre
Ripley	391	74 feet	5 pounds
Rock	1,225	67	5.5
Big Green	7,342	237	12.7
Mendota	9,730	80	16.4
North	277	78	17.8
Delavan	1,813	57	47.0
Eaugalle	530	14	58.2
Elizabeth	712	30 (est.)	62.3
La Belle	1,117	46.5	64.2
Fox	2,456	25	77
Pepin*		10	79
Koshkonong	9,890	11	103.8
Tichigan	741	15	133

Table III Continued

Lake	Acreage	Depth	Yield per acre
Wingra	310	14	138.4
Little Green	467	26	227
Waterloo Mill Pond	90	15	250
Leota	28	15	428
Bass	65	14	569

*Greenbank, 1949

Size of a body of water, of course, has its import on production. The unit of fishing gear is relatively more effective in small bodies of water than in large. This can be seen by the greater pounds per surface acre yield recorded for such small lakes as Leota, Bass, and the Waterloo Mill pond where 250 to 569 pounds per acre have been caught. The high yields of small, shallow bodies of water are probably an expression of carrying capacity which is estimated to be 300 pounds per acre. Anything less than this figure is likely a partial harvest of the standing crop due to escapement.

In reviewing the pounds per acre yield figures for all the Wisconsin waters, three lakes stood out as being completely out of harmony with the yield patterns evidenced by the other waters in the state because they so greatly exceed those of comparable waters. These lakes, Monona, Waubesa, and Kegonsa, produced a mean average of 130.3, 439.0 and 267.5 pounds respectively per surface acre of water annually more than double the maximum anticipated yield for similar lakes (Table IV). This situation is a consequence of the domestic fertilization which these waters receive from the city of Madison, for the lakes would not under ordinary circumstances by their character alone be considered to be good rough fish producers. The fertilization apparently is manifested in plant and animal products which are readily available to the rough fish, principally carp. Similar situations have reached the literature regarding certain German lakes which after fertilization from domestic sources become great rough fish producers (Hasler 1947).

Table IV

Rough Fish Production in Heavily Fertilizated Lakes

Lake	Acreage	Depth	Mean Yield
Monona	3,480	74 feet	130.3 lbs.per
Waubesa	2,034	34	439.0 acre
Kegonsa	3,145	31	267.5

Lake Waubesa with a mean yield of 439 pounds per surface acre is the outstanding example of the effect of domestic effluent on an aquatic community. The lake receives effluent directly from the Madison metropolitan sewage district which serves a population of approximately 100,000 people. The fertilization promotes tremendous growths of algae which require constant chemical treatment to render the lake shore habitable. In all probability the carp utilize the algae and other vegetable growth directly and they are thus able to exist in tremendous densities. The other two Madison lakes show degrees of this condition.

Character of controlled rough fish populations:

What has been the effect of this continous control on the rough fish populations? Have any facts become apparent through the history and observations of the rough fish control program? It can be said that the rough fish populations as a whole are a cyclical lot both by reason of the fishing pressure that is exerted on them and the natural conditions that prevail. A typical example of this situation can be seen by an examination of the histogram of the annual pounds per acre catch recorded for Beaver Dam lake and Lake Waubesa (Figure 5). The variation such as experienced in these waters prevails in most of the rough fish waters even in the face of approximately equal annual fishing effort.

The Beaver Dam lake fishery fluctuates because of a periodic winterkill which strikes this shallow body of water. Winterkill took a heavy toll in 1936 and again in 1945 after which a three year period elapsed before the fishery was restored to previous productivity. The shallow waters, such as Beaver Dam lake, to which the rough fish seem to be adapted are often subjected to winterkill. As a result the strength of year classes varies considerably from year to year.

The causes for the fluctuation of the Lake Waubesa fishery are not so evident. The history indicates that there were three dominant year classes that had reached the fishery im the 14 years recorded in the histogram. This can be seen in the modes of the histogram and in a review of the catch reports which show that there was a dominance of a particular size of fish (number three) in those years in which the modes occurred. As to causes for this fluctuation, there is reason to suspect the extent of development of aquatic vegetation at spawning has some influence on the creation of a year class. In rivers and flowages fluctuations in water level are known to cause a failure in year classes.

Intensive fishing also affects the character of a rough fish population. Where the control is nearly or totally effective and the population is drastically reduced, as it would be in a small body of water, the effect is like a release cutting on a stand of timber. The reproduction shoots up and when the waters are next fished, some years later, they usually harbor a population uniform in size.

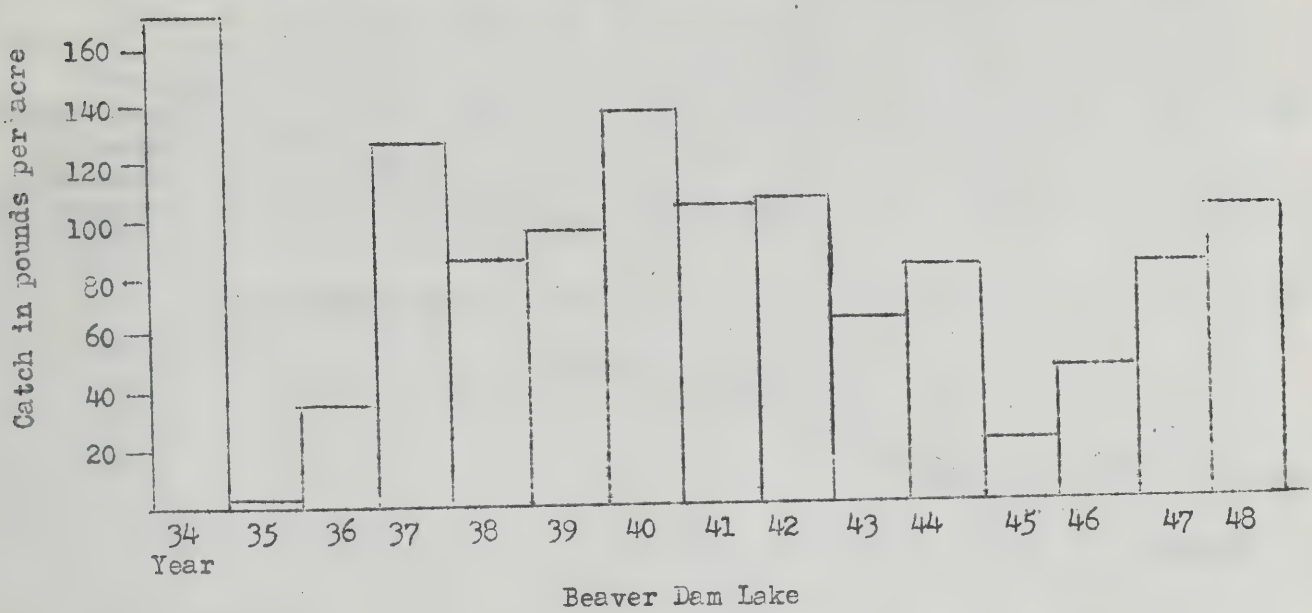
Growth and catchability:

Of considerable importance to managing a fishery of any kind is the growth of the fish and the effect of this growth on the fishery. A limited amount of information was gained on this subject by a review of the growth data that Frey (1941) presented and in the progress of year classes through the fishery as witnessed in the fishermen's reports. Further information was evident in the length frequency analyses compiled from actual observation.

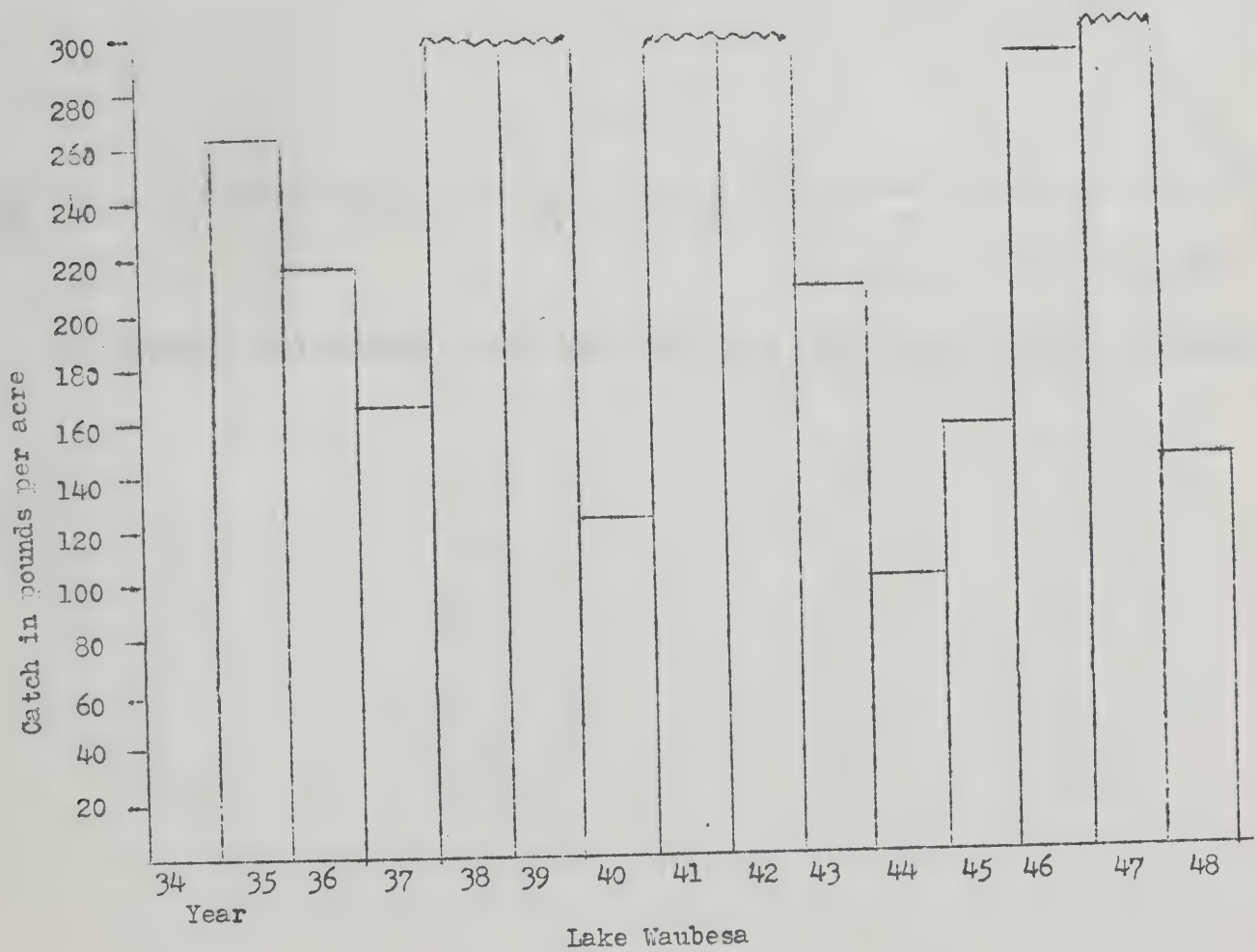
Frey's growth data is reproduced in Figure 6. Included, also, is an estimate of the growth of carp obtained by deduction by following a year class through the fishermen's reports of the size of the general run of fish in his catch in Lake Waubesa. Since the scales of carp are difficult to read, the use of any scale data is impractical beyond the first few years of life; thus, the hypothetical data deduced from fishermen's estimates of fish size finds good use for estimating ages of older fish. Fishermen use a designation of jumbo, number one, two and three, and minnows to describe

Figure 5

Histogram of annual rough fish catch in pounds per acre for two Wisconsin lakes showing dependence on year classes



Beaver Dam Lake



Lake Waubesa

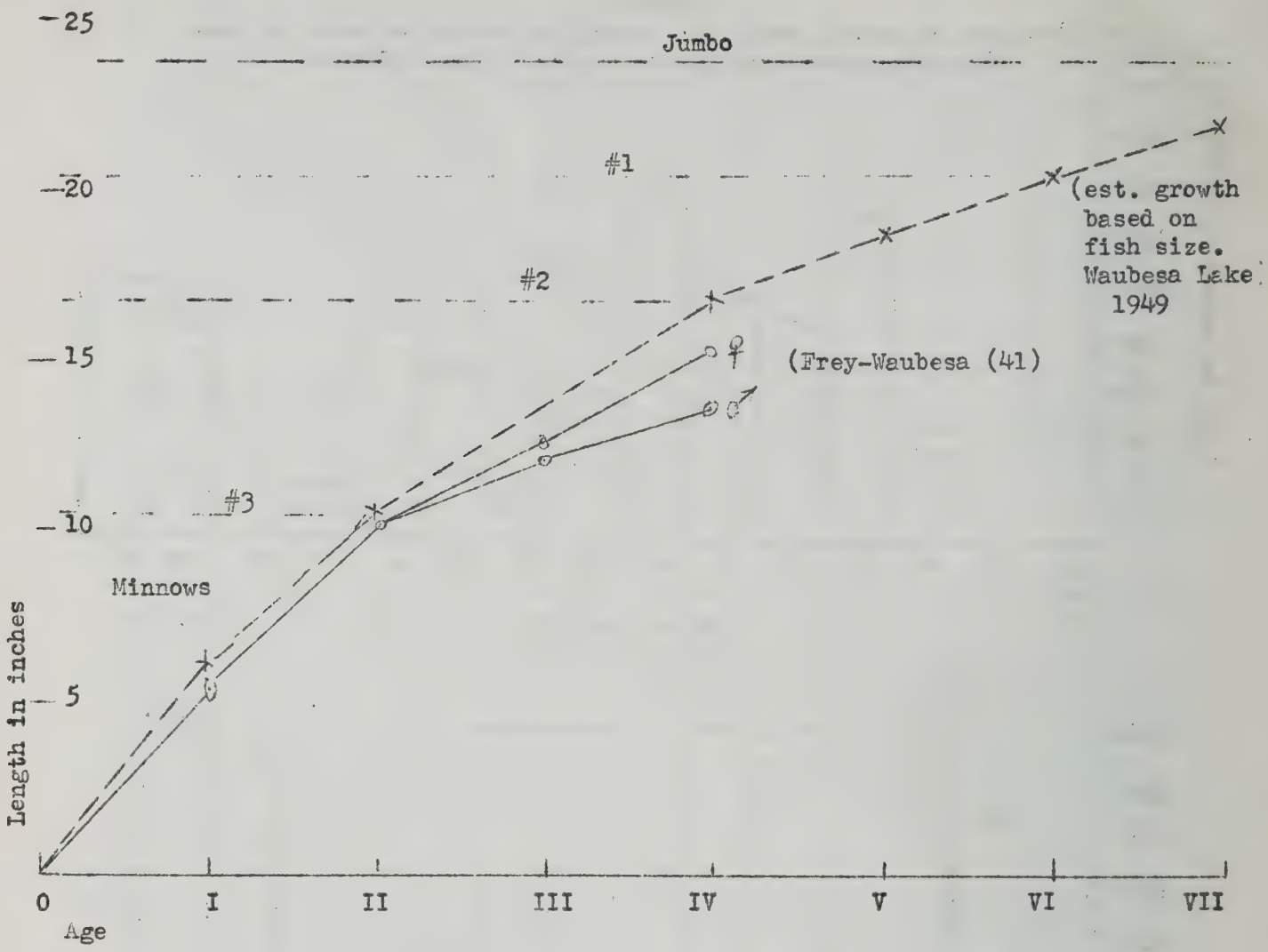


Figure 6. Growth of carp from Frey (1941) and growth deduced from fishermen's estimates of fish size.

size. The carp were caught as minnows during the first and second summers following the tremendous hatch of early summer in 1936. At this size they were less than half a pound each. In the third summer the fish began to appear as number three fish and continued to enter the fishery at this size through the fourth summer. As number three fish, they are one-half to three pounds in weight. In the fifth summer they were number two fish (three to five pounds) and by the sixth summer the fish began to enter the fishery as number ones (five to seven pounds). From length-weight data available it was estimated that these fish were the equivalent of 21 to 23 inches as number one, 18 to 20 as number two, 12 to 17 as number three and less than twelve inches for the minnow group.

This general growth pattern conforms to estimates of the fishermen and appears to prevail for the rough fish waters where the year classes were traced through the fishery, hence, it assumes management value. It should be pointed out that the fish begin to enter the fishery in impressive poundage yields in the third or fourth summer following the appearance of a large year class. They are one and one-half to three pounds and 14 to 18 inches in length. This can be seen by an examination of the histogram reproduced in Figure 7 which is probably a typical histogram. It illustrates that the fish do not enter the fishery much before they become late number three. Similar evidence is available in Table V in which the mean size from a number of samples has been computed. Since there is a positive kurtosis, it should be remembered that the largest percentage of the fish would be less than the mean. The one exception in Table V is the Rock river which only recently experienced a winterkill.

Table V

Average Size of Carp From Random Samples Collected From Various Localities in the State

Lake	Year	Size Sample	Average Size
Kegonsa	Fall - 48	141	18.9 inches
Kegonsa	Spring - 48	205	19.3
Koshkonong	Spring - 49	78	19.1
Rock River & Bark River	Fall - 48	403	19.9
Monona	Spring - 48	309	18.8
*Rock River - Dodge County	Winter - 47	310	13.6
Wisconsin River	Fall - 47	186	21.4
Poygan	Spring-48	168	22.2
Waubesa	Fall - 48	225	19.9
Waubesa	Spring - 48	196	19.8
Waubesa	Spring - 48	121	20.4
Mud	Spring - 48	266	19.6
Waubesa	Spring - 48	317	19.4
Waubesa	Fall - 47	147	20.2

*This area suffered a winterkill two years previously.

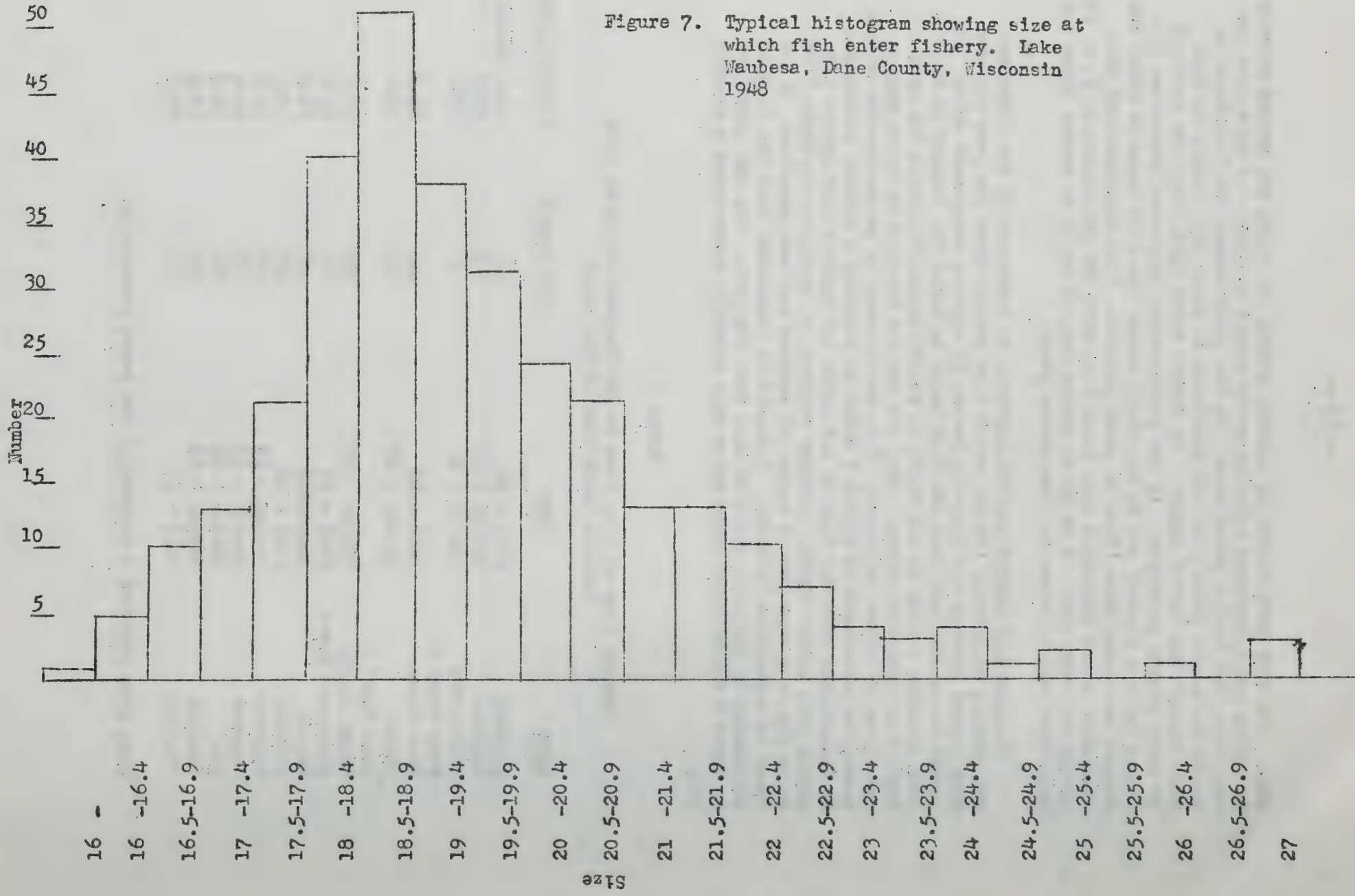


Figure 7. Typical histogram showing size at which fish enter fishery. Lake Waubesa, Dane County, Wisconsin 1948

A glance at the histogram in Figure 7 leads to the belief that the fishing gear must be selective, taking only fish in excess of the minimum appearing in the histogram. This, however, is not true. Only the fish in their first summer cannot be caught. All other year classes can be taken by the nets, but large catches are not made until the third year. It seems that the fish are more prone to "bunch" in huge numbers then, and they are thus more vunerable. When three years old at least a part of the population is mature, and at spawning they are particularly vunerable.

Frey (1941) in his growth studies found that the Lake Waubesa male carp became mature when two to three years old, and females at three to four years old. This is a fish approximately 14 to 17 inches in length. The histogram of fish sizes shown in Figure 7 thus would appear to be a catch of purely mature fish. The significance of maturity to the carp fishery is obvious.

The effect on environment:

The rough fish control program is, of course, founded on the assumption that the carp are harmful exotics. That they damage or destroy the environment in which they abound to the detriment of the game fish is the common accusation. References have reached the literature which link the carp with the dearth of aquatic vegetation and turbidity (Kahn, 1929 and Ricker, 1940) and circumstantially they have been associated with the poor fishing conditions of a number of southern Wisconsin lakes.

In the course of these observations data was gathered on the actual effect of the rough fish on an aquatic environment. For that purpose several lakes which have carp problems were observed at the peak of development of the aquatic vegetation (late July and early August) and the results were recorded for comparative purposes (Table VI).

Table VI

Extent of Development of Rooted Submerged Aquatic Vegetation in Selected Wisconsin Lakes

Lake	Variety Plant Species	Abundance of Plant Species	Depth to which Plants Grow	Limiting Factors
Delavan	13	xxxx	12 feet	Apparently None
Mendota	10+ (est)	xxxx	14	Apparently None
Monona	11	xxx	6	Algal Growth Carp
Waubesa	1	xx	3-4	Algal Growth Carp
Kegonsa	5	xx	6	Algal Growth Carp
Koshkonong	9	xxx	5	Carp Turbidity
Beaver Dam	1	x	1	Carp Turbidity
Mud	2	xxx	6	Carp, algae
Cherokee Marsh	1	xx	3	Carp, Turbidity

Note: x - occasional; xx - frequent; xxx - abundant; xxxx - very abundant

Of the ten water bodies observed those with the least carp problem had the greatest variety and intensity of development of plant species and the clearest water. There is little doubt that in the other waters, which did

not have such extensive development of the submerged aquatics, that the carp were a very important factor because their depredations were evident in the form of torn up weeds, denuded weed beds and exceptional turbidity. In Lake Koshkonong there was one particular bay in which sago pondweed had come up so densely early in the summer that a motor boat could not navigate. Yet when the observations were made in August only occasional stems remained. Beaver Dam lake, a large shallow lake was so turbid that the Secchi disk became invisible at a depth of six inches. It does not seem mere chance that there was only one minor patch of vegetation present. There was in that year an exceptionally large year class of three year old carp which presumably were directly concerned in the problem.

There is a gap in the available information on the effect of carp or rough fish on a game fish population. Literature and hearsay are, however, very positive in their assertions that the rough fish are harmful in an aquatic environment. To this can be added no more than further opinions, based in part on evidence and in part on theory.

It seems that the carp, like most other fish, are principally plankton feeders for the first two years of life, after which time they turn to a bottom and vegetable diet (Frey, 1941 and Black, 1945). It is at this stage that their depredations become most evident. Certainly when young, the carp are competition for the young of other fish for the available plankton supply. As the diet trends more toward vegetation and bottom forms, the direct competition is not so real. In all probability they compete with the fishes which derive much of their food supply from the bottom, but they would likely affect other fishes indirectly. With the disappearance of vegetation on which insects feed and develop an important source of food would be lost to game fish. Similarly, with the destruction of the aquatics, much of the protection required by the young fish would be lost. Then too, there is the outright competition for space, certainly very important when carp become dense. It stands to reason that the presence of a large concentration of rough fish would have a depressing influence on the game fish stock. There are, however, other considerations to be made.

Without the presence of the carp some of the large shallow lakes would become so choked with weeds that they would be an outright nuisance effective enough to completely inhibit navigation and fishing. The possibility of occurrence of this problem was demonstrated in the situation found in certain of the bays in Lakes Koshkonong, Delavan, and Monona, where vegetation formed a solid mat. The carp browse on the vegetation and in a sense effect a natural control where chemical control might otherwise be necessary.

The presence of the rough fish also manifests excess fertilization. In an almost direct conversion of plant to animal matter, fertility is manifested in a harvestable product sooner and in larger quantities than would be possible if the other units in the food chain were introduced. Therefore, the carp are of value to the lower Madison lakes which receive domestic effluent for, by binding up the plant matter in a harvestable product, they are removing from circulation vast quantities of fertility which would likely render the algae nuisance an even worse problem than it is. The potential can be seen by considering the mean yield for Lake Waubesa where an average of 439 pounds of fish per acre have been harvested annually.

Evidence of the actual effect of carp on the existing game fish populations is limited or lacking. They are probably of some value as forage in

their first year of existence, for there are certain areas which support a population of only carp and northern pike. But after the first growing season they are too large to be of value as forage. In a winterkill lake, carp and game fish will develop and prosper simultaneously. In the heavily fertilized lakes in the Madison chain and most other rough fish waters there continues to be a large harvest of game fish along with the rough fish harvest. It is believed that the rough fish when present in reasonable densities tend to inhabit an otherwise unoccupied niche in aquatic ecology but when extremely abundant tend to infringe upon the game fish.

Rough fish management:

There was seen to emerge from the statistics and the natural history a pattern which can be utilized to formulate a management plan. The pounds per acre harvest, the growth of fish, the effectiveness of the fishing gear are all of use in this respect. These facts have been classified and summarized in Figure 7.

Figure 7

Classification of the Rough Fish Problem on the Basis of Anticipated Control For Management Purposes and Expected Yield

No Problem	Complete Control	Semi Control	Continuous Control
	Small, shallow lakes (1-100 acres)	Medium sized shallow lakes (100-1000 acres)	Large, shallow lakes (over 1000 acres)
	Small deep lakes (1-100 acres)	Medium sized deep lakes (100-1000 acres)	Large deep lakes (over 1000 acres)
Yield:	300 lbs. per acre	200 lbs. per acre	100 lbs. per acre
Recurrence of problem	5-6 years	3 years	annual

It is founded upon a certain number of generalizations. Fish are assumed to enter the fishery in large numbers by the third year. The units of fishing gear are assumed to be more effective in the smaller bodies of water and shallow bodies of water are assumed to be the better producers of rough fish, all of which have a bearing on the immediate and the continuing effect of control.

The effectiveness of rough fish control may be considered in the following order: small deep lakes, small shallow lakes, medium-sized deep lakes, medium-sized shallow lakes, large deep lakes, and large shallow lakes, using an arbitrary depth of twenty feet to distinguish between a shallow and a deep lake, and using acreage values of 1 to 100 acres as the size limits for small lakes, 100 to 1000 acres as medium lakes and over 1000 acres to define large lakes.

The small, deep lakes are seldom a carp problem and when they are their small size assures ease of control. Low poundage yields would be expected varying with the effectiveness of the fishing. The small shallow lakes, of which there are many in the form of mill ponds and various small artificial lakes are often carp problems, but these very characters permit "complete control". A yield of three hundred pounds per acre is typical.

Among the medium sized lakes escapement is greater, and lesser yields can be anticipated. A yield of two hundred pounds per acre is a suitable maximum figure for the shallow lakes and the deeper ones would logically produce much less than this figure.

The great escapement experienced on large bodies of water necessitates continous fishing to effect control. The escapement is ample to replenish the fishery each year and the production remains unchanged, except for cyclical variations, from year to year. In this category a yield of one hundred pounds per acre would be typical for the shallow lakes and less for the deep lakes.

Control of rough fish, or management, can be reduced to convenient descriptions which encompass most of the waters of southern Wisconsin. They are as follows: no problem, complete control, semi-control, and -- continuous control. In terms of management this means that the fish are "fished out" when complete control is referred to and heavily overfished in the case of semi-control and cropped off in the case of continuous control. In terms of time it means a generation or two will be required to restore the rough fish population to its former abundance where the fish are "fished out" as they are in complete control. Thus, it is estimated that a five to six year period must elapse before further fishing would produce equivalent results. Where a state of semi-control can be achieved and a reasonably large brood stock remains it is estimated that within a generation (three years) the stock will have grown to its former abundance.

The management of rough fish waters should be founded upon a consideration of the effectiveness of control. Conveniently, the waters in which a state of complete control or semi-control is achieved, fall heir to the fish management organization because fishing is unprofitable, but where the fishing is continuous, where "carp farming" persists, there is the makings of a commercial fishery. Overfishing can only be achieved at great expense and no permanence is guaranteed. Such waters can most economically be managed as commercial fisheries capable of sustained yields.

Summary and conclusions:

The rough fish industry in the state of Wisconsin is large with an annual production in millions of pounds. Centered in the southern part of the state it reaches its greatest production in the shallow rivers and lakes. In waters of this type a production of five to five hundred pounds per acre of surface water is commonly experienced. This production is a function of the size, depth -- the fishability and the productivity of the various waters. On a continuing or sustaining yield basis the production of rough fish water ranges from eighty to one hundred pounds per acre annually; the larger production figures, probably in excess of two hundred pounds per acre, are an expression of the carrying capacity.

Fertilization from domestic sources appears to more than double the yields. Growth and habits of the fish usually permit their harvest in the third or fourth year of life, at which time they are fourteen to eighteen inches in length and mature fish. Rough fish are definitely reckoned to have an adverse effect on an aquatic environment, but their presence is thought to be a desirable evil in certain instances where the control of aquatics and the excess fertility is desirable. There is a pattern evident in the production of rough fish which can successfully be utilized for management purposes. An analysis of yields shows that complete control is possible for small shallow lakes (100 acres), semi-control for medium-sized lakes (100-1000 acres) and continuous control for large lakes (in excess of 1000 acres). The former two classifications lend themselves to fish management activity, whereas, the latter appear to be permanent commercial fisheries, which can be operated on a sustaining yield basis.

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RECENT WILDLIFE DEVELOPMENTS IN RIVER BASIN MANAGEMENT

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U. S. Fish and Wildlife Service

Presented at the 11th Midwest Wildlife Conference on
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The subject which was assigned for my discussion today is recent wildlife developments in river basin studies.

The Fish and Wildlife Service established its Office of River Basin Studies in order to deal with developments affecting fish and wildlife in connection with flood control, navigation, irrigation or other water control projects. Soon afterwards, the Congress passed Public Law 732 making it our duty to study any project having to do with water manipulation or development.

Most of you are familiar with our work in connection with Corps of Engineers and Bureau of Reclamation projects. Recently, however, we have had some new problems brought to our attention that we believe are of important significance to all workers in the fish and wildlife field. We welcome this opportunity to bring these matters to your attention.

Fundamentally, these new problems are concerned with a direct conflict of land use between agricultural and wildlife. The problem is especially complicated in view of the fact that our conflict is with the farmer who provides the bulk of our hunting. It is our conviction, however, that this conflict can be resolved if both the wildlife and agricultural interests will cooperate in its solution. We further believe that this solution can be of benefit to both groups.

The first point I would like to discuss is the problem of water use with respect to irrigation, a common problem in arid portions of the west, but one which crops up even here in the midwest.

During the past few years, drainage of muck lands for agriculture has been extensive in parts of Michigan, Wisconsin, and Indiana. These projects have been successful, and the growing of specialty crops, such as mint, onions, celery or other truck has been very profitable. So far as we know, there has been no major complaint from fish or wildlife interest over the development of these lands although losses to upland game or waterfowl may have been involved.

Recently, agriculturalists have found a combination of drainage and overhead irrigation of muck lands to be a more profitable method of farming. In at least one instance that has come to our attention, the farmers in one of these areas have installed pumps in a nearby stream to provide the necessary irrigation water with the result that the stream has been completely dried up for extended periods during the summer. Since the stream in question had been a valuable trout stream, the resulting damage to the fishing was called to our attention. We have been informed by representatives of this state that such water diversions are becoming common. Under present laws, there is nothing that the Fish and Wildlife Service can do about this matter. To our knowledge, very few of the States in the eastern half of the country have adequate water laws and it is doubtful that the Conservation Departments can do anything about a diversion of this kind.

As a solution to this and similar problems that are certain to arise, it appears that each State Conservation Department in the region should investigate the legal status of water rights in that State. Perhaps a joint study by all of the states represented here should be made to determine the best form of water regulation. Once a satisfactory water law is prepared, an active campaign to procure the passage of this law should be on the program of all conservation organizations in the State. Such a law should take cognizance of the needs of fish and wildlife and the needs of agricultural and of all other water users. Without such active participation by the conservation agencies, it is possible that their needs may be overlooked. It has happened in the western states - in some, fish and wildlife use of water is not recognized as a beneficial use.

A far more serious problem than this, as we see it, is the widespread interest on the part of the agricultural interests in an intensified program of land drainage.

The drainage program has two important manifestations. The first of these is the agricultural drainage program authorized by the Congress and being planned by the Corps of Engineers. During the past few months, we have been asked to furnish our views regarding the effect of major drainage on projects in Missouri, Illinois, Wisconsin, Iowa, and Minnesota. As an example of this, I should like to refer to a project in Minnesota which we are studying currently. In the Flood Control Act of 1936, Congress directed the Chief of Engineers to make a study of Chippewa River, Shakopee Creek, and Hawk Creek in the interests of flood control. Recently, major drainage has been included as a possiblility for investigation.

Our investigations revealed that these streams drain an area of considerable importance to migratory waterfowl. Marshes are still numerous in the area although considerable drainage has been accomplished during the past 30 years. Most of the marshes that could be drained economically have already been eliminated. Some of the best marshes in Minnesota are found at the headwaters of Shakopee Creek and they can be drained only by channel deepening for approximately 30 miles. If the project is completed, these fine waterfowl marshes will be lost. From the standpoint of conservationists, we view this project with alarm. We recognize the value to the farmer, but believe that because of the fish and wildlife values involved, the decision should not be based on flood control and drainage values alone. We have an obligation to point this out to the Corps of Engineers, and we have done so. When weighed in the balance these fish and wildlife values may be found to be more important than the agricultural values. At least, we do not believe that we are being unreasonable when we ask that full consideration should be given to wildlife as the project is being planned. Such consideration is justified by the large public values involved in these marshes. Of course, we are ready to recognize that in time, as the populations increase, these lands may be more valuable for agriculture than they are for wildlife. But, in that case, these lands would still be available for future agricultural use when the National need for such use arises.

Lastly, I wish to discuss pothole or marsh drainage. During the past four years many of the Service's field men have reported seeing evidence of an extensive program of drainage in the prairie pothole region of Minnesota and the Dakotas. Since drainage of marshes has such a serious effect on

waterfowl, this has been a matter of vital concern to this Service. The job of investigation this problem was assigned to the Office of River Basin Studies.

Inspections of the pothole country of the eastern Dakotas and western Minnesota have been made. Considerable time has been spent looking over areas in Ottertail and Wilkin counties, Minnesota; Richland and Sargent counties in North Dakota; and Marshall and Day counties in South Dakota. In the following few slides I would like to show you a few samples of what has been found. -- SLIDES.

During the course of our investigations, we interviewed a large number of farmers, as well as Soil Conservation district supervisors, Production and Marketing Administration representatives, and Soil Conservation Service officials.

As a result of the inspections and the interviews, we believe that the following statements can be made:

1. Our studies in these three states have confirmed the fact that a widespread and large scale program of drainage is being carried out. What Schoenfeld said in his Field and Stream article "Goodbye Potholes" applies in some respects to a much greater area than just Day county.

2. Practically all of these potholes have value to waterfowl, fur animals or upland game. Even if they dry up early, they contribute to waterfowl production and their heavy vegetation provides winter cover for pheasants. Studies by Service field biologists have very definitely proven that the production of waterfowl per acre is at its very highest on the pothole holes of one acre or less in size and this production progressively decreases as the size of pothole or marsh increases.

3. The program of pothole drainage has been stimulated by at least three factors. The first is the excellent economic condition of the average farmer as a result of high crop prices. Second, the developement of machinery which makes it cheaper and easier to drain the marshes. Third, and of major importance, the various subsidies and encouragement given to drainage by the agricultural agencies. That their subsidies are the compelling reason was admitted by more than one farmer.

There are several aspects of the situation regarding subsidies and encouragement of drainage by agricultural interests that are difficult to understand.

The most confusing has to do with the question of why there should be any kind of governmental subsidies which would encourage the farmer to cultivate additional land on his farm until there is a National need for additional food crops. If one is to believe what one reads in our daily newspapers it would appear that the biggest problem facing the American farmer today has to do with the disposition of farm crop surpluses which are beginning to pile up to a point where strong governmental support is necessary to keep farm crop prices from complete collapse.

To many of us it seems that converting these potholes and marshes into crop lands simply adds to the problem.

It may be that some of you are wondering why the wildlife management profession has not anticipated this drainage development and does not have a complete alternate program to present to the agricultural profession. The truth is none of us who lived through the great drouth period of the 1930's ever conceived a pothole and marsh drainage program for the semi-arid prairie lands of the west beyond that already in existence. All emphasis in that section until the past few years was on a water conservation program, in fact, during the worst period of the above mentioned drouth years many of these potholes now being destroyed were the only spots on many farms that could support a hay crop and furnish grazing. Farmers besieged our Service to develop more farm ponds. There was even a very strong local demand on many of our wildlife refuges that they be thrown wide open to public grazing because these areas still had green vegetation resulting from the high-water tables the Service maintained. We cannot help but think that the memory of man is very short indeed.

I might add that with the agricultural situation as it is, many of us have believed that there would be a rapid slackening of this drainage work this year, but on the contrary, reports from our field men indicate some increases in some localities in the tempo of this work during the past summer.

We must, of course, recognize that most farmers have a perfectly normal desire to farm all of the land which they own and on which they are required to pay taxes. The nuisance created by a pothole is usually a compelling reason for drainage. Ordinarily drainage of potholes and marshes which could be considered economically sound occurred shortly after the land was brought back under cultivation.

It is probable that we in the wildlife profession are partly to blame for having failed to recognize the need for a positive program designed to encourage the preservation of marshes, especially those located east of the Dakotas and which often present a surplus water problem and the need for initiating such a positive program is the main reason why this subject is up for discussion here today.

Since a great many of our farmers hunt, I am sure that they would regret seeing all waterfowl lost because of the drainage. The dull drabness of the average farm would be relieved and the life of the farmer made more pleasant if a place could be found on his farm for: a marsh with a few birds; an occasional patch of brushy cover with a brood of pheasants; or a fence row of multiflora rose from which emenates the song of the brown thrasher. Yet each year the mania for slick and clean farming of every single acre is succeeding in making our agricultural land more bleak and unattractive, as well as less capable of sustaining wildlife. It is high time that these values be considered and made a part of the farming program. A few wildlife biologists working with the agricultural agencies might bring large rewards to the farmer as well as to the sportsmen.

A positive program is going to be difficult to develop and will require constructive thinking on the part of everyone concerned. I believe that the Midwest Wildlife Conference can set up a group to study the problem and work up a tentative plan of attack. I am sure that the Fish and Wildlife Service will be glad to aid in working up such a plan and will do all within its power to carry it to successful completion.

2/17/50
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THE ROLE OF THE AQUATIC BIOLOGIST IN A POLLUTION ABATEMENT PROGRAM

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The disposal, or breaking down, of domestic sewage and many other types of wastes is dependent upon living organisms and is thus largely a biological process. Living organisms are responsible for many of the complex interactions resulting from stream pollution and are a major consideration in the improvement of streams used as sources of water supply. The science of biology is, therefore, of prime importance in the solution of problems of stream sanitation, sewage treatment and water supply.

Aquatic biology includes many branches and specialties, among which the following are of importance in pollution investigation: aquatic botany, algology, protozoology, planktonology, nematology, parasitology, cytology, histology, physiology, entomology, malacology, ichthyology, herpetology and ecology. It is in the latter field that the aquatic biologist may make many of his most important contributions. It is important that those working for pollution abatement have an ecological concept and an understanding of the necessity for using biological methods when dealing with biological problems.

In complex problems of this type, it is essential to work with nature. Working without regard for natural processes is a costly, wasteful and senseless procedure which is certain to result in failure in the long run. All life and life processes are vitally influenced by the environment. When the environment is changed, a whole series of events are set in motion which may have important and unforeseen consequences. In the past, man has tampered with natural phenomena without much consideration for the consequences. Lumbering, burning, drainage, grazing, farming and industrial developments, as carried out in the past, have produced a chain of events which were not dreamed of by those who initiated them. Many of our present troubles exist through lack of consideration and failure to grasp all phases of the problem.

The surest way to destroy an animal or a race is to destroy its environment. Flying squirrels cannot be raised in a clover field, Jersies in a desert, trout in an eroded arroyo, or bass in a cesspool. In view of past events, it is apparent that the complex problems of water pollution control should be studied from all angles. A group of scientists having a diversity of training and experience and working as a team can best handle this complex problem. Water pollution control activities require the use of several branches of science, and no single group can foresee all the possibilities or avoid all the pitfalls.

Present stream quality standards upon which pollution classifications are based, and by which pollution abatement or natural purification are measured are: biochemical oxygen demand (B.O.D.), dissolved oxygen, suspended solids, coliform concentrations and population equivalents. The approach of the aquatic biologist is along three lines: (1) to measure the purifying ability of the aquatic life in receiving waters; (2) to discover biological indicators of various degrees of pollution; and (3) to determine the amount of waste which may be added without causing a breakdown of the essential purification processes and the resulting production of undesirable conditions affecting other uses.

It is not proposed that biological studies shall replace tests or indices now in use but that they shall supplement and strengthen them in order that a

more comprehensive and adequate attack may be made on stream sanitation, sewage treatment and water supply problems.

Stream Sanitation Studies

Surveys of pollution conditions will consume a considerable portion of the aquatic biologist's efforts. Methods used by chemists and bacteriologists are largely standardized. This has yet to be done for much of the biological portions of the surveys.

The introduction of domestic sewage and a large number of wastes into a stream produces a series of complex interactions which are largely biological and may be recognized as dependable criteria of stream conditions. Changes are produced in the character of the stream bottom, in the physical and chemical properties of the water, and in the distribution, competitive relations and populations of organisms. Definite zones, with their characteristic fauna and flora, are produced and can be recognized by trained biologists. A general overall biological reconnaissance can be valuable in determining overall conditions, in detecting zones of pollution, and in studying the extent and severity of pollutional effects over a considerable period of time.

Sewage pollution alters the normal conditions of food supply, dissolved oxygen, bottom materials, turbidity and the chemical character of the water. Many plants and animals found in clean water are exacting in their habitat requirements, while others are more tolerant, or even prefer a bottom of high organic content. Under pollution conditions the former group must migrate or die. The latter, for whom these conditions are favorable, will, due to the absence of many competitors and predators, thrive and build up huge populations characteristic of pollution zones. They thus serve as clues to the intensity of pollution or the degree of recovery. It is these huge populations of organisms which bring about the natural purification of streams and which serve as indicators of pollution. In judging pollution conditions, the aquatic biologist does not depend on a single species, but rather on ecological groups or communities, or the relative abundance of pollutional forms in the total population.

Studies of the population of bottom organisms are of outstanding value in determining the extent and relative degree of pollution, the location of sludge beds and the progress of self-purification. Chemical and bacteriological samples taken over a short period give data only on conditions at the time the samples were taken. They are of little or no value for indicating average conditions over a considerable period or indicating the most severe conditions which may be only of short duration.

Because plankton organisms have short life histories and are free floating, samples of plankton serve as indicators of conditions for only short periods. They can give no information about severe situations of the past, brought about by the occasional release of large amounts of toxic materials. Bottom organisms, especially those which move only short distances and which have an annual life history, are of outstanding value for indicating pollution conditions over considerable periods of time. By their use, severe conditions prior to the survey can be detected and something of the pollutional history of the stream during the past year determined. A study of the bottom forms gives information on past critical conditions, the oxygen supply, the extent of severe pollution and zones of recovery.

Fish, especially the young, or the non-migratory species, are valuable indicators of stream or lake conditions. The composition of the fish population is indicative of water quality. An absence of fish, the presence of only two or three resistant species, or a dominance of tolerant or resistant species, is indicative of unfavorable environmental conditions. The prevalence of fish parasites and diseases, the growth rate and condition factor, can serve as indices of pollution and recovery.

Studies or determinations of fish and mollusk populations, or populations of other animals of economic or recreational value in polluted and non-polluted areas, make it possible to estimate at least a portion of the gain or economic loss resulting from pollution. Data of this type are valuable in arousing popular support for pollution abatement programs, as they are readily understood by a large segment of the population. Of importance also are studies for determining the role and value of various forms of aquatic life in the natural purification of streams and the effects of various toxic industrial wastes on these organisms and their purification activities.

Another function of the aquatic biologist is to develop, standardize and use bioassay methods for determining the toxicity of industrial wastes to fishes and other organisms. Chemical tests are inadequate for determining the potency of many complex industrial waste effluents containing substances which are acutely toxic to aquatic life. Bio-assays which involve the use of living organisms as reagents are, perhaps, the most useful and reliable tests for making toxicity determinations in connection with the control of water pollution from such wastes. Toxicity to aquatic life is an important objectionable feature of many industrial wastes discharged into streams, so that the usual chemical or bacteriological tests for the measurement of pollution and of the pollutional strength of effluents may be quite inadequate or inapplicable to these industrial wastes. With complex wastes, bioassays are simpler than chemical tests for rapidly or readily determining toxicity hazards for routine control purposes.

When standardized for general use, a program of bioassays could be used by all industries on a given stream as a means of controlling the toxicity of their individual effluents. Thus, their total discharge could be absorbed by the stream without creating undesirable conditions, while adequate safety factors could be maintained for meeting unusual circumstances.

Sewage Treatment

Sewage treatment plants for the disposal of domestic sewage and many other wastes are dependent for their operation upon the activities of organisms. Here more than elsewhere, therefore, there is a need to create environmental conditions conducive to the survival, growth and reproduction of those organisms of value in the reduction of sewage wastes. Studies are needed to add to the knowledge and understanding of the biological processes in sewage treatment plants, to determine what organisms are present and contribute to or interfere with their efficient operation. Efforts should be directed toward increasing the efficiency of treatment plants, and the sanitary quality of their effluents, by encouraging the desirable and controlling the undesirable organisms by various means, including manipulation of the environment.

Animal and plant communities, and environmental conditions below outfalls of sewage treatment plants, might be used for evaluating the efficiency of the plants and the quality of their effluents.

Water Supplies

Taste and odor problems are of outstanding importance in providing a potable water supply. Aquatic biologists who have training and experience in plankton studies, especially algae and protozoa, are especially fitted to detect and identify those aquatic organisms which interfere with the safe, economical and otherwise satisfactory use of water for domestic and industrial water supplies and for recreational and commercial purposes.

By a microscopic examination of the flora and fauna of the water the aquatic biologist is able to detect the presence of surface water organisms in ground water supplies which indicate pollution of that ground water and to discover the source. Through screening and field tests, it should be possible to improve upon existing methods and materials, or to discover, develop and test new biological or chemical measures for the control of those organisms which impart disagreeable odors, tastes, color and turbidity to drinking water, clog water works filters and foul distribution systems. There is a possibility of the discovery of a material which will be more or less specific for taste and odor-producing organisms, yet which will have little detrimental effect on organisms of importance from a recreational or economic standpoint. Additional studies are needed on the basic causes of water blooms and means by which they may be prevented.

It is felt by some that we should have a method for the removal of phosphorus. A better approach would be to develop a method for the recovery and use of various fertilizing elements which are now being discharged into our streams and lakes. There is acute need for the conservation of our elements of productivity. At present, our population is concentrated in large metropolitan areas and our substance is being run out to sea or buried in silt deposits.

There is also need of further investigation into the fate of waterborne parasites (both human and animal) in sewage treatment plants and streams, the development of means for their destruction and the control of their intermediate hosts and reservoirs.

SUMMARY

1. The purification of sewage and many other types of waste is dependent on organisms and is thus largely a biological process.

2. The aquatic biologist can make a definite contribution toward solving environmental sanitation problems.

3. An ecological approach, a diversity of training and experience, and team work, are absolutely essential.

4. The aquatic biologist studies the effects of pollution on the stream and the life within it, the ability of the stream to purify the various wastes in it, the role of the various forms of life in the purification process, and the value of some as indicators of degree and type of pollution.

5. Biological surveys are of value in gaining an over-all picture of pollutional conditions and serve as a basis for planning future investigations.

6. The introduction of wastes into a stream produces a series of complex interactions which are largely biological and may be recognized as dependable criteria of stream conditions.

7. Bottom organisms are, perhaps, the most reliable indicators of past pollutional conditions and critical periods.

8. A knowledge of the role and value of various organisms in the process of natural purification is a prerequisite for determining effects of toxic industrial wastes on the purification process.

9. Studies of the populations of fishes and other animals of recreational or economic importance in polluted and non-polluted areas furnish valuable data on the effects of pollution which are more readily understood and appreciated by the general public than are many other indices of pollution.

10. Demonstrated damage to recreational facilities, sport or commercial fishing serves as one of the best motivators of public action for pollution abatement.

11. Bioassays of industrial wastes are, perhaps, the most useful and reliable tests for detemination of toxicity and for the regulation of waste discharge into streams so that the capacity of the stream to absorb wastes toxic to aquatic life is not exceeded.

12. Investigations essential to the maintenance of a suitable water supply include examinations for the detection and identification of organisms which cause turbidity, color, tastes and odors in drinking water, clog water filters and foul distribution systems.

13. Screening and field tests are needed for the discovery, development and checking of additional biological or chemical means for the control or elimination of taste and odor-producing organisms. An effort should be made to develop specific measures which cause a minimum of harm to other organisms of recreational or economic importance.

14. Because aquatic biologists are trained in limnology and stream ecology they are well fitted for interpreting data obtained in water pollution surveys.

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PROBLEMS IN THE DEVELOPMENT AND MAINTENANCE OF FARM PONDS AND THE IMPORTANCE OF PONDS TO WILDLIFE

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In 1942 the Ohio Divison of Wildlife set up a Federal Aid Project to assist landowners in building demonstrational farm ponds. Approximately 200 of these pond areas were developed before the project was terminated in 1947. 175 of these areas were established and leased for a period of 5 years as State Game Refuges. The costs in development were shared by the State and the landowners. Later, 25 farm ponds were built and the surrounding areas developed entirely by the State under 25-year leases. Now the Wildlife Division has an agreement with most of the Soil Conservation Districts to give assistance in development of the pond area after the pond has been built under Soil Conservation Service supervision.

The farm ponds built have ranged in size from $\frac{1}{4}$ to 2 acres with the protected areas surrounding the impoundments ranging from 1 to 10 acres. These pond sites varied in type of location from those built on steep slopes in Eastern and Southern Ohio to level lands in Western and Northern Ohio and were concentrated in Morainic Sections of the state.

Advance publicity on this project caused it to become very popular over the State and created a situation which made it difficult for project personnel to select and approve locations that had all the desirable features, especially locations where wildlife would receive optimum benefits. This is showing up today after the areas are 4 to 5 years old. It is not uncommon to find landowners allowing their livestock to frequent the pond areas through an open gate or a damaged fence. The necessity for livestock water and the tendency to follow the path of least resistance probably accounts for this. More supervision which was not always available might have improved the situation. Good locations and dependable landowners have proved that well protected pond areas are a valuable asset in wildlife restoration. It is our opinion that most ponds in Ohio are of limited value to wildlife. Only those ponds which are managed to meet the critical requirements of wildlife, especially game species, will justify the expenditure of wildlife conservation funds!!!

With the aid of slides we will attempt to show some of the problems common to farm ponds built to benefit wildlife.

It has been stated that 90% of the ponds built in Ohio in the past have failed due to dam washouts, rapid siltation or seepage. Benefits to wildlife are negligible unless there is a permanent supply of pure water.

This farm pond will soon be drained due to an extremely large watershed and an inadequate spillway. The spillway is cutting back toward the pond and has only a few feet to go before a washout will occur. Large watersheds result in fast and extensive fluctuation in pond water levels which drown many young muskrats in the den.

This pond has silted in very rapidly due to too much cultivation and consequent erosion in the drainage area. A large portion of the pond area is now grown to marsh vegetation of limited value to wildlife due to inaccessibility. This condition was corrected by blasting a level ditch through the marsh area in the spring of 1949, making it available to muskrats and waterfowl. Assuming that the influence of the level ditch extends 100 feet on each side, the cost of ditching is approximately $75.00 per acre. Level ditching in Wisconsin marshes increased the muskrat yield from 1.3 per acre to 3.8 per acre, as stated by Anderson.

This one-half acre farm pond failed to hold water due to the previous condition of the subsoil. Five tons of a commercial clay product was applied to the fill and part of the pond bottom. To date this has been successful. Results obtained from treating other ponds that had a seepage problem have been less successful. The cost of material needed to adequately seal such ponds makes the repair expensive and impractical in most cases. There is no assurance that a leak will not develop later, due to a break in the seal material by burrowing mammals, crayfish, etc.

Ponds one acre or more in size were found to be productive of more wildlife species and individuals than smaller ponds, and a greater percentage of wildlife present was game species of value to sportsmen. Waterfowl utilized larger ponds extensively and migratory populations of 200 to 500 ducks were common favorably located large ponds.

Of great importance to all wildlife is the size of the protected area surrounding the pond. A large area of good cover surrounding a pond provides escape cover for most wildlife species during the winter when cover is scarce; it provides nesting cover for upland game and occasionally waterfowl; it provides food for many species, and finally it prevents concentration and the consequent high mortality. Ponds attract large numbers of wildlife, including predacious forms, and where the surrounding cover area is small, this population is concentrated and unduly high mortality results.

Improvement on this pond margin consisted of seeding a strip to reed canary grass this fall. In contrast, this pond was fenced too close to the waters edge, thus practically eliminating any wildlife value on this pond. A minimum size of 10 acres is recommended for the cover area surrounding the pond. On this protected pond with a wide margin of cover (it is located in the corner of a 12 acre woodlot), the observer on November 1, 1949 flushed 14 black ducks and counted 4 muskrat houses. Wood ducks nested in the artificial nest box erected on the elm tree standing in the water.

A single row of multiflora rose was planted inside the fence around this 10 acre pond area in 1947. A band of pine for winter cover was planted adjacent to the multiflora rose and at intervals, clumps of food bearing shrubs were spotted in. Additional cover development was done by planting wetland shrubs along a portion of the pond shore. Control of obnoxious weeds on the unplanted part of the area was accomplished by applying lime and fertilizer to stimulate the growth of native grasses.

In contrast, livestock was never fenced from this pond area. An area like this is almost completely valueless to wildlife.

Ponds located close to buildings are of limited value to wildlife. To be of maximum benefit to wildlife a pond should be located at least 300 yards from the buildings. When the buildings are screened from the pond by a woods or a hill, wildlife values are enhanced still further.

This pond was built too close to farm buildings to get the maximum wildlife benefits. Predation and molestation by cats, dogs and humans will have a serious effect upon the wildlife population. Advisory Agricultural Agencies often justify this type of location because other benefits derived from farm ponds. Proximity of ponds to buildings often increases recreational activities such as swimming and picnicking.

"Build a pond - hunt, fish, trap, swim, boat, skate and picnic" has become a slogan of those encouraging pond building. If wildlife benefits are the primary basis of justifying the expenditure of wildlife conservation funds for pond building, then this multiple use concept must be revised. Where ponds and adjacent a areas are used extensively for recreation or any other purpose involving regular human activity, the value to wildlife diminishes greatly.

The availability of home sites for breeding wildlife species is important. Natural cavities for wood ducks were scarce near ponds and nest boxes were erected to encourage wood duck nesting. Richard R. Roaederer's survey (Ohio Project 58-R) of the utilization of these nest boxes by wood ducks revealed that 50% of the boxes properly erected were utilized the first year by wood ducks. While this does not compare with the 90% success reported by Johnson in Massachusetts marshes, this degree of use may greatly increase the numbers of native hatched ducks in inland Ohio. Eight wood ducks hatched from this nest in the summer of 1949 according to Roaederer. This box contained 6 unhatched eggs. This box contained egg shells. Egg fragments were found in this nest and the owner observed 12 wood ducklings on the pond. It is interesting to note that in another nest located on a pond in a large woods 31 unincubated eggs were found.

On a State-owned tract of land where permanent food and cover is plentiful, small hillside ponds were built. Observations indicate that during drought periods these ponds are extensively used by deer and raccoons.

Many ponds were built in morainic areas. Oftentimes, where the pond was created by damming the outlet to a morainic pothole, the pond completely filled the pothole basin so that banks for muskrat denning sites were eliminated. Initial planning can correct this condition by establishing a lower water level. Without bank denning sites, there is constant danger of dam destruction from muskrat burrows in the dam. In Ohio, trapping of muskrats on the refuge has been permitted in order to reduce this hazard. Generally, this has not solved the problem. The installation of a 1" by 2" mesh welded wire fence along the face of the dam, extending at least 1 foot above and 3 feet below the normal water line, has been effective in controlling muskrat burrowing in dams. Installations have not been made long enough to determine the life of this type of fence. The presence of brushy vegetation in the pond (willow, button bush, osier) provides bases for muskrat houses and escape cover for waterfowl, and relieves the denning pressure in the dam by muskrats.

A discussion of the value of farm ponds to wildlife would be incomplete without mention of wildlife numbers which occur when <u>optimum wildlife habitat</u> is provided.

Protected ponds yielded an average of almost 10 muskrats per acre. The maximum yield of 32 muskrats from an acre pond indicates the high potential when a favorable alignment of factors occurs.

Minks were trapped on many farm ponds. The maximum yield of 7 minks were taken from a 7½ acre pond--a morainic pothole dammed to form a pond--with a border of marsh vegetation and a central nucleus of buttonbush. Raccoons are abundant on ponds though untrapped.

Waterfowl were reported from 90% of farm ponds under observation. A maximum of approximately 500 ducks were observed on one pond during migration. Two broods of wood ducks were hatched on a 1.5 acre pond.

A maximum of 25 sora rails were flushed from a 1/3 mile marshy margin of the above mentioned 7½ acre pond during fall migration. It was common to flush 12-15 soras daily during the fall around this pond. Snipe were common during migration and woodcock were recorded with regularity from some ponds.

A pond, to benefit the greatest number of wildlife species and individuals, should possess the following characteristics:

It should be remote and undisturbed by man, livestock or pets. It should be one acre or more in size and half the margin should be shallow and grown to marshy vegetation. The other half should have abrupt banks high enough for muskrat denning. Pondside shrubs provide food and den protection. A low island or peninsula invites waterfowl. Woods near ponds provide home sites for wood ducks and raccoons. The pond cover area should contain at least 10 acres to provide nesting and winter cover. Travel lanes (fence rows for upland wildlife, streams for aquatic wildlife) connecting with other food and cover areas increase use of pond area. Ponds near large streams or lakes are used extensively by waterfowl. Only ponds which meet the critical needs of wildlife are worthy of wildlife conservation dollars.

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